The CRUSHED STONE JOURNAL

PUBLISHED QUARTERLY

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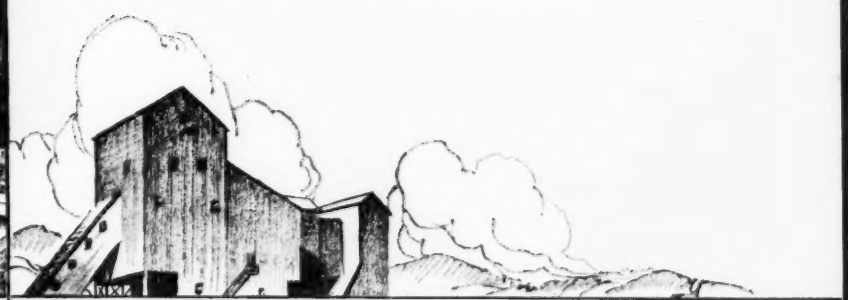

June • 1946

Official Publication
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The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

Contents

EDGEWATER BEACH HOTEL, CHICAGO

Selected for Annual Conventions, January 27-31, 1947

By action of their respective Executive Committees, the EDGEWATER BEACH HOTEL, Chicago, Illinois, will be host on January 27, 28 and 29, 1947, for the 30th Annual Convention of the National Crushed Stone Association, and on January 30 and 31, 1947, for the 2nd Annual Convention of the Agricultural Limestone Division.

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THE CRUSHED STONE JOURNAL

WASHINGTON, D. C.

Vol XXI No. 2 PUBLISHED QUARTERLY JUNE, 1946

The Responsibilities and Rights of Employers in Labor Controversies[1]

By the Honorable WAYNE LYMAN MORSE

**U. S. Senator from Oregon,
Washington, D. C.**

• The important significance of Senator Morse's observations at the time of our annual meeting were fully appreciated by those who had the privilege of hearing them. Developments in the labor field since then should increase interest in the Senator's viewpoint.

I DON'T propose to talk to you this morning as a politician because if you knew me as well as the people in my state know me, you would know that I am not very politic. I feel that in the critical period ahead, what we need in the United States Senate are not politicians but men who are willing to run the risks of exercising an independence of judgment on the great issues that face the country. I tell you that is sorely needed throughout government. As I sit in the Senate and watch various political plays, I know we need more independence of judgment in government. I think if more office-holders would pay less attention to re-election and recognize that in these days it ought to be considered, after all, a very slight sacrifice to sacrifice re-election in order to stand for sound principles of government, we would have truly a more representative government.

Neither do I speak to you today as a politician who seeks to arouse agreement. Rather, I want to think with you about some of these problems of labor relations, knowing well in advance that you will not agree with me on every point. But I think it is only going to be out of honest disagreement and sincere attempts to reconcile differences in points of view that we can meet the great problem in the field of industrial relations which confronts us. We shouldn't mince words about it, nor should we lose sight for a moment of the fact that this truly is the period of economic destiny for America. I have two or three major premises that I want to lay down.

The first major premise that I stand ready to defend, and that I shall continue to fight for, is that you cannot have political democracy retained in America unless you also retain economic democracy. Let me be perfectly specific about what I mean in regard to economic democracy. Unpopular as the term may be in some quarters, I have said for years, and I shall continue to say it until I find some rebuttal for it—and I have yet to find a sound challenge to the premise—that you cannot have political democracy except under a capitalistic system of economy. The reason I say it (and that is what I mean by economic democracy) is that if you substitute for the private property economy any other form of economy, you must necessarily turn to some

[1] Presented at the 29th Annual Convention, National Crushed Stone Association, Netherland Plaza Hotel, Cincinnati, Ohio, January 28-30, 1946.

form of statism as far as your economic life is concerned. I don't care what form it is, the end result is inevitably the same; be it communism, be it fascism, be it some form of national socialism, the end result is the same. What is that result? The subordination of the individual to the state; the adoption of a principle of government whereby the government itself is master and not servant of the people of the state.

Let me tell you, you can have that economic result functioning under nice sounding labels of democracy, and that is the way it will be produced in this country if you have it. The State Economy boys will not use the slogans of national socialism as they were used in Germany. They will not use the slogans of communism as they were used in Russia. They will not use the slogans of socialism as they were used in England. They will use nice sounding constitutional Bill of Rights slogans in their attempt to establish statism in this country. The test is, who is it at any given time that should tell us what our economic life can be. If that test has to be answered by saying that we must function in the business world in America in accordance with the over-all dictates of a central government, then I tell you that at that point you will have lost economic democracy.

I talk the same language when I talk to labor unions as when I talk to employer groups such as this one. I say to labor, and have for years, not only vocally but in decisions and in writings: The only way American labor can continue to improve its standard of living and maintain the individual dignity of the worker and the freedom of the worker is under a private profit economy. Let me tell you this contention—cliché as it may sound, it is a pretty fundamental truth. Let me tell you further that we cannot afford to permit a situation to develop in America where an increasing number of workers, citizens and consumers, have a little, and only a little, interest in private property. I would say to any group interested in preserving the private property economy that probably among the first five major domestic issues of today is the problem of home ownership. Give me a country with increasing millions owning their homes, with a vested stake in private property, and I will have less concern about the perpetuation of our economy than I have today. With millions wanting to own homes, I say to American industry, you have the greatest opportunity of the century to increase the interest of our people in the private property economy. They want to go forward with industrial statesmen to the end of solving, and solving as quickly as possible, this problem of home ownership in America.

The next premise that I want to lay down is that I think you—and I don't mean you gentlemen in the room, I mean you as representatives of business—just as representatives of labor, if you have got an ounce of sense in regard to the future problems facing your economy, will take the pressures off of Congress to pass strait-jacket labor legislation that will lead to a control of your economy. Even though that legislation is in the form of compulsory labor control legislation, I suggest that American business has much more to lose than American workers from such strait-jacket legislation. Why do I say that? Because there are more workers than there are of you, and once a form of revolution starts against an economy, the masses will in the long run dominate. I think there are businessmen in America today who are so short-sighted as to the irreconcilability between compulsory labor legislation and the private property economy that they do not see that when they bring pressure to bear upon the Congress for strait-jacket labor legislation, that the same devices can be turned against them and their interests—and will be. Read your history again. Note what happened in Germany and Italy and Russia. Much of it was accomplished by compulsory legislative controls. In the beginning a minority in Germany took over the German legislative machinery and proceeded to pass the type of restrictive legislation that they wanted, and pretty soon all groups lost their freedom. The pattern was repeated in Russia and Italy.

Now let me be even more specific. I happen to be one who believes that if we are going to perpetuate the private enterprise economy, if we are going to make the principles of voluntarism inherent in free collective bargaining work, we have got to practice them and not just prate them. There is too much prating these days about free collective bargaining and too little practicing of it, on both sides of the table. We have been conditioned through the war to turn more and more to government to solve economic problems for us, and this has had a tremendous effect on the psychology of our people. It has had a tremendous effect on the economic habits of the country. It is understandable and almost natural that in this aftermath period of the war, there should be a tendency to continue to turn to the government to solve the hard cases. Yet if our form of economy is going to perpetuate itself, we are go-

ing to have to solve the hard cases through the exercise of good faith, collective bargaining and voluntary arbitration between labor and industry. There are no men in government who can do as good a job as the parties can themselves if they will.

May I say, and say quite kindly, there are no great men in Washington. You ought to get out of your heads the notion that government officials are an answer to your prayers. There are no great men in Washington. Give me an audience, a cross-section audience, of 10,000 Americans, and give me momentarily dictatorial powers, and I can select out of that 10,000 audience ninety-six men just as competent as the ninety-six men in the United States Senate. When I say that I pay a great complement to Democracy. It is a pretty good test of the strength of Democracy. I can do the same with the executive branch of government, too. Yet, somehow, because as a people we are not wishful thinkers and great escapists, too, we like to believe that the men in Washington are supermen. They are not. Many of them are not even men of average ability. How we as a people and as individuals like to run away from trouble, or at least turn it over to somebody else. We like to forget about economic pain; we like to postpone at least the unpleasant job of coming to grips with stark realities in any field of activity.

That is what we are doing in the labor field, and so the next proposition I want to lay down is that I think it is not in the interest of the private property economy to settle labor disputes by governmental compulsion. Whatever experience I have had in the field, I know a little bit about compulsory arbitration because I served for two years on a compulsory arbitration board—the NWLB. I defend the Board, though it made its mistakes, functioning as a compulsory arbitration tribunal during the war, because during a war when the very life of a nation is at stake, there is only one supreme law. There can be only one law of supreme importance, and that is the law of national necessity. In war, under our constitutional form of government, as I said in decision after decision, the law of national necessity must be supreme, irrespective of whether in a given case in peacetime we would say that justice was rendered in the decision.

I was honest about it. I told you in decision after decision that I didn't think it was a very just decision, judged from the standpoint of peacetime standards. However, I pointed out that you can't have the same degree of justice in wartime as you are entitled to in peacetime. War isn't made of that sort of stuff. When you have to act with a tremendous speed, and in keeping with certain artificial standards that were set up by the government in the interests of the national security, you can't always work out a just decision in a given case. So I said in case after case, "We think it is, by and large, considering all factors, a fair and reasonable decision. We think it does rough justice to the parties, and we render it on the premise that this decision is necessary, in our judgment, in order to promote a more effective prosecution of the war."

Sure (I can read, too), some very unpleasant things were said about me, but that will always be the case, I think, if you try to do your duty under such rules, laws, and procedures that fixed the powers and duties of the NWLB. But I don't want that type of procedure in peacetime, and so while a member of the Board, I said over and over again, "Just as soon as possible when the war is over, I want to see this compulsory procedure go out of existence. I want to see free employers and free workers return to the voluntarism of peaceful procedures for the settlement of their disputes, reserving to them the basic right, and the fundamental right under normal conditions, to exercise economic force by way of strike or lockout, if they really feel that in a given case that is the only way that they can obtain a just settlement.

I think there are three or four premises which, for purposes of this discussion, we ought to consider basic. One is that a revolution is taking place in the minds of men the world around. Why ignore it? You aren't going to be able to get away from it. We are entering into an era now of the greatest enlightenment in the history of man. We have developed in America the most enlightened workers of any peoples of the world. It is a direct result of 150 years of free education. This enlightenment which is a direct product of the great publicity forces, educational forces, and advertising forces, has been wrought over the years upon the consumers of America. Free education and trade advertising have produced a great deal of wishing and desiring on the part of workers and consumers for a better standard of living. Unless you want to stamp out the forces of education, unless you want to try to stop the common men and women of America from thinking, you are going to find it impossible to prevent their ever pressing demand for an increasing share of the products of their labor. That is basic economic-labor fact and industrial statesmen who do

not recognize it, I think, will pull a Sampson act in the house of private industry.

Now, I happen to be one who intends to fight for the preservation of a capitalistic system of economy in America if for no other reason than for the reason that I am satisfied, as a student of history, that common men and women will enjoy a better standard of living under such a system than under any state economy that can possibly be devised by politicians. But that does not make me blind to some of the mistakes of employers in the field of labor relations. As I have appeared before labor groups—sometimes in the midst of their "boos"—and pointed out to them that they have a great interest in the profit system, I now point out also to you that there is no other economy that really develops and protects to the same degree as our American system the dignity of the individual.

We should do what we can to get the people of this country to become fully conscious of the fact that political democracy and a profit system economy are inseparable. Destroy the profit system economy and you destroy political democracy for the very simple reason that you have to substitute then for a private enterprise economy a state economy. That means Government dictation not only over business but over workers and employers alike. We have national socialists in America who want to see our private enterprise system destroyed, and they are not looking with disfavor upon the widespread labor struggles of today. I say to labor groups, "Whether you know it or not, unless you work out more peaceful procedures for the settlement of your disputes, you are playing right into the hands of those who seek to destroy the private enterprise system, which you allege you want to maintain, and you are helping along the cause of the regimenters who want to impose upon us a state economy." There is no freedom for labor under such a system. The state becomes the workers' master, not its servant, under any breed of fascism, communism, or national socialism.

But, ladies and gentlemen, if you are going to make the private-enterprise system work, then I tell you, employers as well as labor are going to have to make the voluntary system of collective bargaining work. They are going to have to make some concessions and sacrifice some prejudices if they are going to make it work.

I want to talk now in terms of some specific suggestions that I think American industry is going to have to accept if it is going to make the principles of voluntarism work in the field of labor relations. Needless to say, I am very much opposed to that segment of industry today that is arguing for and trying to have adopted various forms of compulsory arbitration. They will lose their shirts, so to speak, under compulsory arbitration because they seek to substitute for independent action on the part of industry and labor, governmental decrees as to how industry shall function. Although a plausible case can be made for compulsory arbitration on paper, the major objection to it is that it won't work. It won't work because, as long as employers insist upon being free men, and as long as workers insist upon being free labor, they are not going to accept a compulsory arbitration decree, once they are convinced that it is rooted in injustice.

The labor movement is basically a social movement. Let me make clear that I do not mean a socialistic movement, but rather a social movement. Or to put it another way, it is a great human movement with so many factors that it cannot be put in a legislative strait-jacket. It is one thing to legislate against specific abuses of the labor movement. Such legislation is not only necessary from time to time in order to protect the public's interest, but such legislation will receive the support of labor, businessmen, farmers, and consumers generally.

However, on the other hand, such legislation as compulsory arbitration legislation, which has the effect in the last analysis of substituting governmental decree for free collective bargaining, voluntary arbitration, and economic action on the part of industry and labor, is bound to have the opposition, in the long run, of all economic groups, particularly industry and labor. Thus, you will find most industrial leaders and most labor leaders opposed to compulsory arbitration because they see in it an attempt on the part of government to regiment the economic life of the country, and, further, they are realistic enough to know that the spirit of independence, the love of liberty, and freedom of economic action are so basic in our American way of life that any legislation which seeks to stifle them is bound to break down. Volumes of legislation and hundreds of prisons will not prevent free labor and free employers from striking and locking out because in the field of labor relations we are dealing in a very real sense with freedom itself. Both labor and industry fear—and I think rightly so—governmental dictation of labor relations. Such governmental controls as compulsory arbitration are characteristic of totalitarian states, be they communistic or Fascist, and there are

forces within our Government today in this country which are unwilling to pay some of the prices of freedom, and hence would like to see a governmentally regimented economy.

Labor and industry oppose compulsory arbitration because they well know that the social and human facets and implications of the labor movement cannot be directed or controlled successfully by the adoption of legal analogies. I doubt if anyone has pleaded more than I have for a judicial approach to the final settlement of labor disputes, but I have always been careful to make the reservation that the judicial approach must be upon a voluntary basis and not a compulsory one. Under a compulsory arbitration approach the arbitration tribunal inevitably becomes the dictator of economic policy, with the result that if its decisions are enforced inherent managerial rights of industry and free collective-bargaining rights of labor are destroyed. Under such a system we would find a constant challenge to government in a field in which, in my opinion, government is least qualified to judge with finality.

I do not think we should ever lose sight of the fact that freedom of economic action on the part of both employers and labor is a very precious right, high on the list of American liberties. In my judgment it is so basic in the psychology of our people that any attempt to destroy it by legislative compulsion will result in so many various types of resistance that any such legislation is doomed before it is even written on the statute books. Free labor and free industry will see in it the danger of loss of economic liberties which, over the long years, have been more beneficial to the development of the American standard of living than could possibly have been the case if such freedom had not existed. After all, the right of free men to organize and bargain collectively and to strike or lock-out, if necessary, has been a great check against exploitation. Don't forget that Government can be an exploiter, too, but usually it takes a very long time to remedy the exploitations of Government.

It is very fallacious to argue that compulsory arbitration promotes Government by law. We should not assume that every proposal which seeks to control human and economic activity by way of legislation is consistent with the ideal of Government by law. It is frequently too difficult to get the layman to see the limits and confines of proper governmental regulations of the affairs of free men. Usually the point can be made clear only when the Government seems to transgress our liberties to such a degree that we can see in bold relief the danger of governmental tyranny. However, when Government seeks to control the economic lives of industry and labor in the field of labor relations by way of compulsory arbitration, we can be sure that a spirit of noncompliance will manifest itself time and time again, and to such a degree that such legislation will weaken rather than strengthen government by law. In my judgment, a movement for compulsory arbitration in this country would result in a serious set-back to the very dramatic advancement of procedures for the peaceful settlement of labor disputes which is going on throughout the country today. For instance, there is a great increase in the use of voluntary arbitration mediation and conciliation. Good-faith collective bargaining and the settlement of labor disputes in direct negotiations between employers and labor are advancing with such strides that all students of the labor movement are thrilled with the advance. For the Government to step in, however, and substitute itself as a compulsory arbitrator of labor disputes would change the very nature of the type of peaceful procedures which the parties are now using to an ever-increasing extent in the voluntary settlement of labor disputes.

One of the many objections to the Burton-Ball-Hatch bill is that it is designed to develop compulsory arbitration. If I were an employer, and I wanted to buy for myself the maximum amount of labor trouble, I would invest my money in lobbying for some compulsory arbitration proposal or support some such proposed legislation as the Burton-Ball-Hatch bill. I think that bill would give me the best assurance that I would have constant labor turmoil in my plant. My plea to you is that, if you want to keep the private enterprise system—and we must keep it if we are going to keep our form of government—then veer away from these proposals that are being made in the present crisis which would seek to put labor relations of this country in a legislative strait-jacket.

I won't dwell longer on that major premise. I am on record on it, and hence, so far as I am concerned, I shall not be voting for compulsory labor legislation that would supplant action by the parties on the basis of voluntarism.

That doesn't mean that I think government has no interest or no responsibilities in the field of industrial relations. It has many, and the members of Congress and the President of the United States have very definite responsibilities in relation to those problems. I want to address myself to those

in a moment, but before I do, I want to draw what I think is a very clear-cut line between controversies in the field of wages, hours and conditions of employment and controversies on the other side of the line that affect legal and property rights of the parties thereto and of innocent third parties. In the latter field, you cannot have government by law unless you have a government that assumes its responsibilities over that field, but you cannot have free collective bargaining, and you cannot have, in my judgment, the private property economy, if you have a government that over in the field of wages, hours, and conditions of employment, tells you what those wages, hours, conditions and prices, and all the rest of the economic rights that you have, shall be. I agree with Mr. Walling that when you are dealing with so-called minimum standards, you are dealing with a social problem that the majority of the country as a whole has the right and duty to express itself upon in the form of legislation, but when you get above that basic social policy which the people will determine as of any given time, then I say the function of government should be limited to the field of legal rights and not to the field of economic policy —that it shouldn't participate in the field of economic policy by way of compulsion. On this point I have had the following to say on the floor of the U. S. Senate:

"If we are not going to use compulsory measures then what hope is there through voluntary methods? May I say next that in my thinking on these problems I insist on drawing a line between two types of labor controversy: A controversy which involves the social and economic implications of the labor movement, as those implications relate to hours, wages, and conditions of employment; and issues which involve the legal rights of innocent parties and third parties. As to that latter great group, as I said in my foreword to Teller's new book about to come off the press, in the field of legal rights—and I will give you some specific examples of what I mean in a moment—I think it is the obligation of government to maintain government by law, and pass such legislation as is necessary to protect those legal rights. But over in the field of wages, hours, and conditions of employment I want to see a Government hands-off policy to the maximum extent possible. I want to see labor statesmen and industrial statesmen sit down around a truly free, collective bargaining table and, on a basis of voluntarism, come to agreement as to what conditions will prevail between them.

"Labor and employers must keep in mind the fact that there are significant differences between the legal rights of parties to labor disputes and the legitimate social and economic objectives of such disputants. As to the former, such as the right to protection of property and person from unfair labor practices engaged in either by employer or union the public's interest is paramount. The protecting of such recognized and publicly accepted legal rights in the field of labor relations as in other spheres of human relations fits into a pattern of legislative and legal sanctions. It is in this phase of labor relations that judicial processes enforced by government are most effective. This is true because once there is universal public acceptance of and demand for certain patterns of conduct between disputants in relation to their property and persons, legal sanctions through legislation for the protection of such obligations of conduct become feasible and usually necessary.

"However, most of the operative facts of labor controversies do not relate to legal rights but rather to social and economic objectives in regard to which the parties should be allowed the maximum of voluntary action and freedom of choice compatible with the public's interests. Legislative bodies usually create more serious labor trouble than they seek to solve whenever they attempt to place legislative restrictions upon social and economic objectives of a labor program which are consonant with our system of government and the legal rights of persons affected by those objectives even though they may be affected to their economic detriment.

"It is in connection with the economic and social objectives of the labor movement, as they manifest themselves in specific industrial disputes, that the area of conflict between the principles of voluntarism and freedom of individual and group choice as contrasted with governmental compulsion and legislative restrictions, exists. Both labor and industry are constantly confronted with legislative attempts to destroy their freedom of action within the area of legitimate economic and social aims. The public's concern is to be found in its Government maintaining a proper balance between freedom of action on the part of labor and employers to settle their differences and advance their interests by means of free collective bargaining and all it implies in respect to voluntarism, and attempts on the part of labor and employers to abuse their freedom of action by infringing upon well-recognized legal rights of each other and of third parties. In addition the public

rightly looks to its legislators to provide for fair and decent labor standards and for administrative and judicial machinery which will protect those standards. During the war great strides were made by industry and labor in developing procedures of quasi-judicial wartime tribunals set up for the peaceful settlement of disputes. Many procedural, as well as substantive labor law precedents, were established by wartime labor tribunals, notably the National War Labor Board. It is to be expected that out of this experience industry and labor will look to Government to make available to them on a voluntary basis administrative machinery and quasi-judicial tribunals as aids to them in collective bargaining and in the peaceful settlement of their disputes."

When I talk about legal rights—and I have said it, again, in many decisions—I would give you this example, that when an employer or a union signs a contract, it is signed, and it is signed for the period of the contract, and it ought to be enforced. I have never failed, whenever a contract has been before me, to hold the parties to the terms of that contract. I didn't write it. I didn't sign it. If they wrote and signed a bad one, that is too bad for them. But you cannot have a private property economy, you cannot have healthy relations between industry and labor, unless both parties to a contract respect their signature and abide by it. We hear a great deal about labor violations of contracts. We don't hear so much about labor compliance with contracts, yet the compliances are so much more than the violations that a false impression is being given in regard to the violations. However one violation is one too many, and hence I do not share the view of those labor leaders who seem to think that some individual liberty is being destroyed if their government directs its attention, through legislation if necessary, to the enforceability of contracts.

Another example is the jurisdictional strike. I have never heard, in my judgment, a tenable argument that justifies the jurisdictional dispute strike—not one. Why? Because it transgresses and destroys very important legal and property rights. Let me give you a specific example of a case. I remember not so many years ago when the Port of Seattle was tied up tight as a drum. It involved both a jurisdictional type of dispute and another type of dispute, a violation of the contract. The union insisted that as the lumber trucks came to the dock, they would unload at the edge of the dock, and that the workers then would have the right to move that lumber by hand or hand-truck from the edge of the dock to shipside, and then load it onto the sling by hand, and then from sling to ship. Sometimes they would have to move the lumber as far as a city block or a city block and a half, and they didn't want any other workers on that dock touching that lumber.

I wrote a decision in which I expressed myself on both of these points, and I said in that decision what I think labor needs to learn, and that is that the interests of labor, yes, the long-time standard of living of labor in this country, cannot be advanced by any program of economic waste. The fundamental strength of our great economy is its almost unlimited productive capacity, and when any group seeks to impair or impede the development of our technology and our productive efficiency in the name of protecting some long-established labor custom, then I say that that position on the part of labor is a position against labor's own best interest in the long run. And so you will not find me taking the position that labor legislation that seeks to protect legal and property rights should be beyond the prerogative of the Congress; but over here in this field of hours, wages, and conditions of employment, I want to see a government policy based upon a maximum of "hands off." On the point of jurisdictional disputes I have had this to say on the floor of the Senate:

"When I speak about the obligation of government to protect the legal and property rights of innocent parties and of third parties in labor controversies, I think of such examples as these: The jurisdictional dispute. I say to this audience, as I have for years to other audiences, that I, for one, believe that the jurisdictional strike is absolutely unjustified in our country, and I have yet to hear a labor leader who has been able to advance a single sound argument that justifies going out on strike because his union is in a jurisdictional dispute with another union. My record on this issue was made long before I went into politics. I have said in decision after decision, as an arbitrator under a contract, that I would not support a stoppage of work under the contract on the basis of a jurisdictional dispute. I have held that I would not support a union, as far as a picket line is concerned, whenever the picket line is a collusive one resulting from a jurisdictional dispute. A third party—the employer as well as an innocent public—is damaged in his legal rights by jurisdictional strikes. The Government has an obligation in such cases to see to it that property rights of innocent parties are protected by whatever force of law is necessary to protect them in such cases. I consider such strikes a challenge to government by law, and

I have said so many, many times. Thus on the floor of the Senate the other day I said:

" 'I particularly wish to commend the statement the President made with respect to jurisdictional disputes, because I happen to share the view that unless labor, by voluntary agreement, comes forward with a procedure whereby jurisdictional disputes can be settled without strikes, it is the public duty and obligation of the Congress of the United States to establish whatever court procedures may be necessary to settle jurisdictional disputes by legal sanctions and determinations. I say that because jurisdictional disputes impinge upon the legal rights of people not parties to an economic struggle. I hope that this conference will keep constantly in mind the very important line of demarcation between the legal rights of parties to labor disputes and the social and economic rights of such parties. In the latter category I do not believe that strait-jacket legislation can provide us with any permanent solution to the problem. However, government does have the responsibility to see to it that parties in an economic struggle which impinges upon the legal rights of groups or individuals, be they labor or employers, must be prevented from the transgressions against the legal rights of others. I believe that the President made that very clear by implication, if not by exact language yesterday, when he told the conference in effect that some procedure must be found for settling jurisdictional disputes.'

"It has been my hope that labor and industry leaders, as to this particular issue, would work out a peaceful procedure without governmental action. I have hoped that something would come out of the present industry-labor conference on the point. Maybe it will. I have seen no public indication of it."

Let me say this about the voluntary system, it isn't any good at all if you don't practice it. Disagree with me as you may, and probably will, I tell you that, by and large, today in the major disputes that are paralyzing the economy of this country, American industry has not practiced free collective bargaining. I said so before the Labor Committee on Friday when Mr. Charles Wilson was there as a witness in behalf of General Motors, and Mr. Thomas was there in behalf of the United Automobile Workers. I know something about the records of that case, and you can't listen to the witnesses without coming to the conclusion, which I dare say (and I don't speak for them) if not all, the great majority of the members of the committee reached—certainly those that I talked to reached it—that there apparently was no good faith attempt on the part of the company to avoid that strike, so much against the public interest today, by way of collective bargaining. Both sides want a knock-down-drag-out fight now. I say, gentlemen, the public interest cannot permit of it, and I repeat what I said to Mr. Wilson Friday, and to Mr. Thomas: "Sure, I believe in your right to strike and lock out. I don't kid myself as to what this is: It is a strike on both sides of the table. Labor is saying, 'Give us these wage increases we demand, or else'; and industry is saying, 'Take these wage increases we offer, or else,' and the result is, the public interest be damned."

Gentlemen, this is not a period in our economic history, in my judgment, when either labor or industry, if they will use good sense, have any justification for putting that issue up to government, and as I said to Mr. Wilson and Mr. Thomas, if they insist upon putting it up, I, for one, stand ready to meet that issue, and I say it not inconsistent with my view that voluntarism should prevail in the settlement of these disputes. But I say it, gentlemen, because this is not a normal economic period of time. You are still living in a war economy, even though the shooting is over. You are living in a war economy where two great dangers face this country: the danger of inflation and the danger to the whole economy that results from prolonged scarcity of goods. Of course it is obvious that what we need more than anything else to make the private property economy secure today is the greatest production that we have ever had in peacetime in this country, because until you can get those shelves filled with consumer goods, you can't absorb the great surplus purchasing power that exists. Until you can get that money into productive goods, you are facing the danger of inflation and the collapse of the value of the American dollar.

It has been a fight of years' standing. It was a fight before the war. It was a fight during the defense period. It was in 1940, in the ship clerks' case in San Francisco, when that port was tied up for fifty-four days without a ship moving, that I denied a wage increase in which I pointed out that pockets bulging with cheap money are always pockets close to empty stomachs. What American labor and industry should be concerned with today are real wages, and this notion of pegging wages to changes in cost of living is, I think, basically fallacious, because you are not going to have a healthy improvement in standards of living on such a false principle.

Why do I say we can't let them slug it out? If it were just a case of General Motors and its workers,

or steel and its workers, or packing and its workers, or the electrical companies and their workers, if you just had individual cases, then you could talk about letting them slug it out. But as I said to both witnesses Friday and repeat now, what you have creeping over this country, whether you recognize it or not, is, in effect (I care not what caused it), a general production strike on the part of labor and industry. Now, there is one type of strike that no government can permit to exist—it must use whatever force of government necessary to prevent it—and that is a general strike. You never can let industry or labor, in a free society, get by with a general strike. So my plea to those two very important witnesses was this: "What the American people want is the exercise of a judgment in settling these disputes. Sure, they want you to use the voluntary method, but you have demonstrated to me by your testimony that voluntarism around the collective bargaining table is practically an impossibility because of the nature of the deadlock you have reached, and hence, as one who believes in our economic system, I make the plea that you here and now recognize that in order to prevent the spread of this general strike, you should submit the dispute to an impartial voluntary arbitrator."

Did I get anywhere with it? No. I got the old answers. "Well, I don't think we can get an impartial umpire or arbitrator," said Mr. Wilson, to which I replied, "It is a sad day in America, a mighty sad day in America, if we have actually reached the point that we have such a complete lack of confidence in the head of our Government that we aren't willing to trust him to select an arbitrator who will decide the dispute on the basis of the evidence that the parties submit.

"I don't share that pessimism, and I don't think any American has the right to share it, but I say if you feel that way about it, I am a strong believer in the right to exercise the affidavit of prejudice. Would you be willing to let the President appoint a panel of five and you strike two names and the union strike two names, and if either side doesn't strike two names within seventy-two hours, the President shall have the right to strike two names?"

I didn't get to first base. Now, that is ominous, and you might just as well stop kidding yourselves about it. I don't see how any government that justifies the name of being called a government can permit, under these abnormal conditions, this paralysis to go much further.

You say, "What about the fact-finding boards?" Well, there is all the difference in the world between fact-finding and arbitration, as much difference as there is between night and day. What the American people want, and are entitled to, is a judgment, a fair judgment rendered on the basis of the evidence that the parties submit to an impartial mind. That is what arbitration is. It is just as much a judicial process if conducted properly as the judicial processes you see functioning down here in court, except it is a private court. The parties are entitled to have a decision by an arbitrator documented to the evidence presented.

In fact-finding, in the first place you don't have a decision. You have a hybrid. You have some recommendations, and those recommendations may or may not be based upon the evidence submitted by the parties. The parties have no adequate opportunity to rebut or answer them. You don't know what the basis is going to be until you read the recommendations. My chief criticism of it is that it is a mediation procedure, primarily, and not a judicial procedure. I think that mediation ought to be conducted by the parties prior to arbitration. When mediation has failed, in a time such as this when you are dealing with a national economic pattern, I think if you really believe in voluntarism you ought to be willing to practice it and submit these great decisions to the judicial process of arbitration. I intend to continue to fight for that sort of voluntarism because I think the future of our economy is dependent upon how we come out of this present chaotic state.

Now in my proposal, I have said, first, of course, that it must be done on the basis of the understanding that both parties will accept the decision, and that the government will accept it. I say that because I am not so ill-informed as not to recognize that as long as the government is going to deal with price ceilings, then of course an arbitrator who is functioning under the price ceilings must be free to pass upon fair wages as he finds them on the evidence, with the understanding that whatever adjustments have to be made will be made in prices in order to accommodate to the decision. That doesn't mean what Mr. Wilson testifies, namely, that whatever wage increase is given, a proportionate increase in prices should be granted, because nothing would feed the inflationary spiral any faster. Further let me say that I wish that people would be a little more honest about the meaning of the labor movement than some of the labor leaders are in explaining what the labor movement is. Why aren't we honest enough, as students of the

American labor movement, to recognize that the struggle of the American labor movement, a movement of free men, is constantly to improve the standard of living of American workers? Who thinks that we have reached the limit of the potentialities of our standard of living under our free enterprise system? There are great reservoirs still untouched. Why kid ourselves about it. To meet it, business constantly must be challenged to improve its productive efficiency, its methods of operation, so that standards of living on a national basis can be gradually and progressively increased and business still retain the fundamental right of the free enterprise system, namely, the right to make a decent profit.

That does not mean that the bracket between wage costs and profits shall remain constant. The struggle is to narrow those brackets in many industries, and to lift up from abnormally low levels the standard of living of millions in this country. To point a finger at Congress and say, "Oh, but if you go for that you are jeopardizing the profit system," is untrue. My answer is, no, not jeopardizing it; making it possible for it to remain secure, but not agreeing with you that it shall remain constant.

We can remember, in the days before the war, all the talk about taking profit out of war. Well, let's be honest with ourselves about that. We didn't. Our country is bulging with blood money. Profit was taken out for some, but most of those are sleeping under white crosses. I happen to be one type of politician who believes so firmly in the private enterprise system that I say to you disciples of that system: Stop fooling yourselves, if you think the system will survive on the basis of any knock-down-drag-out war on the economic front in the greatest economic crisis of our history. You are sorely mistaken. To American labor, I say, stop fooling yourselves if you think, through the use of economic force, you are going to call the shots as to how we are to meet the reconversion period. I say to both sides, and to the Government, we have got the chance, and maybe the last chance, to demonstrate to the peoples of the world the private profit economy is the best system for maintaining a high standard, a high level so far as living conditions are concerned, for free workers, free employers, and free men.

Joseph H. Jackson

IT IS with deep and sincere sorrow that we announce the death of Joseph H. Jackson, Vice President of the Carbon Limestone Company, Youngstown, Ohio.

Joe, as he was familiarly known to his host of friends throughout the crushed stone industry, died of a heart attack on May 26, 1946, after an illness of five months.

For the first time in many years he was prevented because of illness from attending the annual convention of the Association, held in Cincinnati last January. He will be deeply missed in the affairs of the Association in which he has been active for many years.

Mr. Jackson is survived by his wife; two children, Joseph H., Jr., a lieutenant in the marines during World War II, and Mrs. Lelia Zieger; a brother, Attorney Sidney De Lamar Jackson, Jr., of Cleveland; and a sister, Mrs. Mary Lorain Jackson Thompson of Toledo.

NOTICE

Through error the volume number of the Crushed Stone Journal for March, 1946, was given as Vol. XXII and should have been Vol. XXI. This error is corrected in subsequent issues.

For those who keep permanent files of the Crushed Stone Journal, it should be noted that publication was suspended during the last half of 1945 and resumed again in March, 1946.

Effect of Aggregates on the Fire Resistance of Concrete[1]

By A. T. GOLDBECK

Engineering Director
National Crushed Stone Association
Washington, D. C.

• Aggregates have an important effect on the fire resistance of concrete and the extent of damage inflicted may vary widely due solely to the coarse aggregate used in the concrete. Some aggregates produce serious spalling, others none, and it is important that building codes take such differences into account.

Introduction

Experience gained from observation of the destructive effects of fires and from fire tests in the laboratory under carefully controlled conditions leads one to the inevitable conclusions that all concretes do not behave alike when subjected to intense heat and the differences in their behavior are largely attributable to the aggregates used. Further, it is concluded that the coarse aggregate plays the most vital role in the resistance of concrete to fire. Because of this important effect of the concrete aggregate it will be well at the outset to classify briefly the kinds of aggregates in most common use.

Classification of Aggregates

Aggregates may be classified into natural and artificial, and the natural aggregates into crushed stone, gravel and sand. The artificial aggregates include such materials as slag, cinders and prepared lightweight aggregates such as typified by the expanded shales and those prepared from slag.

A convenient and simple geological classification of rocks from which aggregates are prepared either by natural or artificial means is given as follows:

GENERAL CLASSIFICATION OF ROCKS

Class	Type	Family
I. Igneous	1. Intrusive (plutonic)	a. Granite b. Syenite c. Diorite d. Gabbro e. Peridotite
	2. Extrusive (volcanic)	a. Rhyolite b. Trachyte c. Andesite d. Basalt and diabase
II. Sedimentary	1. Calcareous	a. Limestone b. Dolomite
	2. Siliceous	a. Shale b. Sandstone c. Chert (flint)
III. Metamorphic	1. Foliated	a. Gneiss b. Schist c. Amphibolite
	2. Nonfoliated	a. Slate b. Quartzite c. Ecologite d. Marble

It is seen that there are three general classes of rocks—igneous, sedimentary and metamorphic.

Igneous Rocks

Rocks in the igneous class have resulted from solidification from a molten state, either at the earth's surface or at varying depths beneath it and their structure has been controlled by the heat and pressures existing as they solidified and also by their chemical composition.

The intrusive or plutonic rocks, that is, the deep-seated rocks, generally have a coarsely crystalline structure. Granite is a typical example. On the other hand, the extrusive or volcanic types have solidified quickly at the earth's surface. They generally are fine grained or are glassy, or as in the case of lava they have a vesicular, a spongelike structure.

The term "trap rock" is commonly applied to the fine grained, dark colored igneous rock, the word "trap" having been derived from the Swedish word "trappa" meaning "stair". Rocks of this type are so designated because they break into masses resembling steps. Andesite, diabase, basalt, rhyolite, diorite and gabbro are frequently called trap rocks.

[1] Presented before the Building Officials Conference of America, Rock Island, Illinois, November 27, 1945.

Sedimentary Rocks

Sedimentary rocks are formed by the consolidation of the products resulting from the disintegration of other rocks. Typical of these are sandstones, conglomerates and shales. Also, sedimentary rocks are formed by the accumulation and consolidation of organic remains laid down under water, typified by limestone and dolomite.

Metamorphic Rocks

The term "metamorphic" signifies a change of form or structure. The metamorphic rocks have been produced by the action of heat, pressure, moisture, chemical action, etc., on both the igneous and sedimentary rocks. The so-called foliated types have been so acted upon that their resulting structure has a more or less parallel arrangement of their mineral constituents. The gneisses and schists, for illustration, have a laminated structure and are the metamorphic counterparts of the granites. The non-foliated metamorphic types do not have this parallel arrangement of minerals. Quartzite, marble and slate are examples. Marble has resulted from the alteration of limestone; slate results from the alteration of shale.

All of these different rock types have a well defined mineral composition and structure, and the mineral constituents and the way they are bound together greatly affect the physical properties and structural behavior of the rock itself.

Gravels and sands have been produced by the breaking down of the parent rocks as the result of weathering, glacial action, water and chemical effects and, in general, the same mineral constituents are to be found in these naturally produced aggregates as are found in crushed rock aggregates.

Blast furnace slag is composed largely of silicates and alumino-silicates of lime and of other bases and is produced in the blast furnace used for separating iron from iron ore. The furnace is charged with iron ore, limestone and coke and the limestone combines with the siliceous portion of the ore, thus forming slag.

Cinders used for concrete block and light weight concrete is the clinker resulting from the burning of coal. Light weight aggregates exist in several forms, but, in general, they have resulted from the heating of clay or claylike materials in such a manner that they expand in volume due to included gases. They have a vesicular structure not unlike that of blast furnace slag. Special light weight aggregates are also made from slag.

These various aggregates have widely different mineral compositions as well as different physical structures and it is quite evident that the physical properties of the constituent minerals must impart definite properties to the aggregates which they compose.

Effect of Thermal Coefficient of Expansion

Obviously, one of the most important properties of the mineral constituents of aggregates on fire resistance is the thermal coefficient of expansion. Griffith[1] has shown that the thermal coefficient of expansion of silica-bearing rocks goes hand in hand with the percentage of silica and the following table is compiled from his data:

Table I

COEFFICIENTS OF THERMAL EXPANSION ARRANGED ACCORDING TO PERCENTAGES OF SILICA

(From Tables in Appendix)

Type of Rock	Average Coefficient of Thermal Expansion x 10^{-7}	Percent Silica*
Cherts, quartzites	61	94
Sandstones	54	84
Granitoid rocks	43	66
Slates	44	61
Andesites	36	58
Gabbros, basalts, diabase	31	51

* Calculated from analysis in J. F. Kemp, "A Handbook of Rocks," 5th ed. D. Van Nostrand Co., New York, 1911.

The significance of the thermal expansion of the aggregate in concrete, and particularly of the coarse aggregate, can be well understood when it is remembered that the coarse aggregate occupies a volume of approximately 43 per cent; the sand 32 per cent and the total aggregate some 75 per cent of the volume of the concrete. The coarse aggregate in particular greatly influences the thermal coefficient of expansion of the concrete. Further, it must be remembered that during a fire the intense heat is applied first to the surface of the concrete and this surface immediately tends to expand while the interior of the concrete mass, which is at a lower temperature because concrete is a relatively poor conductor, remains unaffected in length until the heat has been conducted to the interior. High compressive stresses are produced in the surface of the concrete and the greater the expansion the higher are these stresses. When they become high enough, buckling and spalling of the concrete takes place and the reinforcing steel or structural steel in beams

(1) "Thermal Expansion of Rocks" by John H. Griffith, Bulletin 128, Iowa Engineering Experiment Station.

and columns becomes directly exposed to intense heat. Under these circumstances collapse of the structure is imminent because the yield point of steel is greatly reduced by high temperature.

Thus it is highly important that an aggregate be used in concrete which has a low thermal coefficient of expansion and which will reduce surface spalling to a minimum. Tables 2 and 3 are taken from the Iowa Engineering Experiment Station Bulletin 128, previously referred to, and give excellent information on the coefficients of thermal expansion of rocks. It will be noted that in general the trap rocks, (andesite, diabase, basalt, etc.), the limestones and dolomites tend with some exceptions to have a low thermal coefficient and the coarse grained igneous rocks somewhat higher expansion. However, there are enough exceptions to make it difficult to state a general rule.[1]

Limestones in the past have been thought to be poor aggregates for fire protection. This was based on an entirely erroneous idea, for, as a matter of fact, limestones are exceptionally good aggregates for this purpose. They not only generally have low thermal expansion but, in addition, when subjected to intense heat, their surface calcines to a porous, burnt lime which has high heat insulating value and therefore great resistance to the penetration of heat to the interior. Also, limestone concrete, like other concretes having a low thermal coefficient of expansion, spalls with difficulty and these combined properties result in protection of the reinforcing steel or structural steel against extreme heat.

Some aggregates are notoriously bad for use in fire resistant concrete. Perhaps the worst of these is chert gravel, which causes concrete to spall under the action of heat, thus exposing the steel to high temperature and danger of buckling. Chert has roughly twice the expansion of a low expansion trap or limestone. Slag ranks well as a fire-resistant aggregate as do also cinders when they have a low coal content. Likewise most lightweight aggregates offer good protection because of their included air spaces which provide efficient heat insulation.

Aggregates also vary in their strength characteristics such as hardness, toughness and compressive strength but, except in the case of unusually light weight aggregates, the commercially produced aggregates have ample strength and sufficiently strong concrete can be produced with most aggregates by proper proportioning methods.

(1) Reference should also be made to National Bureau of Standards Research Paper RP 1578, "Thermal Expansion of Concrete Aggregate Materials" by Walter H. Johnson and Willard H. Parsons.

The surface characteristics of aggregates also vary from extremely smooth as in the case of most chert gravels to very rough as typified by slag and many crushed stones. This characteristic undoubtedly is important in its effect on adhesion with the mortar, especially during the period of high internal volume change such as takes place under intense heat.

Laboratory Fire Tests

Theory therefore points to the fact that because aggregates vary widely they have a different effect on the fire-resistance of concrete and this fact is well borne out by practical experience and by laboratory fire tests. A brief review of some of the outstanding examples of these differences as they have been revealed in the past will serve to emphasize the importance of the effect of the aggregate in concrete on its fire resistance.

The following is taken from the September 1926 Crushed Stone Journal, "Aggregates, Their Influence on the Fire Resistance of Concrete", by A. T. Goldbeck.

An independent search through the literature on fire resistance would be a big undertaking but fortunately this has already been done by Committee E-4 on Fire Resistance of Concrete of the American Concrete Institute. The salient features of this report as it pertains to aggregates are presented herewith with direct quotations from the report as published in the 1925 Proceedings of the American Concrete Institute.

"Probably the most valuable contribution to the study of the effects of fire on concretes in which the various aggregates are used was the series of tests of the special commission formed by the British Fire Prevention Committee. And next in importance the tests of the Bureau of Standards at Pittsburgh and those at the Underwriters Laboratories in Chicago made jointly by the Underwriters Laboratories, The Factory Mutual Insurance companies and the Bureau of Standards. These tests gave results which correspond with the conclusions drawn from Prof. Woolson's tests which were reported to the American Society for Testing Materials in 1905, 1906 and 1907 and will be reviewed very briefly. * * *"

Tests of Concrete by the British Fire Prevention Committee

The primary object of this series of tests, the most comprehensive thus far undertaken, was to study the effect of fire on concrete made with different aggregates.

"Ninety-two plain concrete slabs 10 ft. 8 in. long by 3 ft. 6 in. wide and 5½ in. thick, exposing 10 ft. by 2 ft. 9 in. of the soffit, were fire tested, while under superimposed loads. Of these, 49 had natural aggregates, the other artificial aggregates. The natural aggregates included six kinds of gravel from seven sources, seven kinds of sandstone, four limestones, and eleven igneous rocks, five of which were commonly classed as granites. The artificial aggregates included five kinds of brick, a burnt clay, blast-furnace slag from two sources, coke breeze and pan breeze from two sources each and clinkers from three (two from bituminous coals, one from anthracite).

"The 67 slabs of reinforced concrete were 11 ft. 6 in. square with exposed soffits 10 ft. square. The two-way reinforcement of ⅜ in. plain round rods, alternately of lengths 11 ft. 3 in. and 9 ft. 3 in. with fish-tailed ends, was placed in various slabs at ½ in., 1 in., 1½ in., and 2 in. from the bottom of the slabs. * * *"

"The fire test period for 44 of the plain concrete slabs was three hours followed by a two-minute application of water from a ⅝ in. nozzle (pressure nearly 50 lb. per square inch). Twelve were similarly exposed to fire without the subsequent application of water. The superimposed loads were 224 lb. per sq. ft. Twenty-two slabs were loaded to 280 lb. per sq. ft. and subjected to four hours' fire and five minutes' application of water. Fourteen other slabs had protective coatings of plaster and (or) concrete applied to the soffit. Most of the slabs were of 1:2:4 mix; there were, however, several in which richer mixes were used and in some instances fine aggregates other than sand were employed.

"The gravels, sandstones, granites and other highly siliceous aggregates were unsatisfactory, while the fine-grained igneous rocks, classed as basalt, dolerite and trachyte gave satisfactory results. The limestones were better than the siliceous aggregates, the fine-grained stone being distinctly better than the coarse-grained.

"Coarse aggregates of clean broken bricks and burnt clays gave the most satisfactory results from strength and resistance to fire. Blast-furnace slag appeared to be almost as good. Pan breeze and clinker were fairly satisfactory as aggregates for plain concrete slabs. In some cases coke breeze used as fine aggregate gave better results than sand in comparable slabs.

"Not all aggregates suitable for plain concrete slabs give good results in reinforced concrete, usually, however, aggregates which are unsuited for one are not suitable for the other. This has proven to be the case with gravels, sandstones, and the coarse-grained and highly siliceous rocks. Those aggregates which gave the best results in plain concrete have proven to be the most satisfactory ones in the reinforced-concrete slabs. Pan breeze and coke breeze which gave fairly satisfactory results in plain concrete slabs did not give satisfactory results in the reinforced slabs.

"Siliceous gravel in equal proportions with basalt for the coarse aggregate in 1:2:4 mixtures did not give satisfactory results in either plain or reinforced concrete. Nor were the siliceous gravel concretes with 1 in. protective coatings of coke breeze, pan breeze or broken brick concretes on the soffit satisfactory in either the plain or reinforced slabs, except in the case of thoroughly dried, year-old slabs. One case of 2 in. protective coating gave satisfactory results with a plain slab. One-half inch of gravel concrete plus 1 in. protective coatings of fine coke or pan breeze mortars as protection to the steel in reinforced-concrete slabs was not sufficient.

"In parallel with the tests of plain and reinforced-concrete slabs the heat conductivity of the various concretes was measured. In 22 of 30 tests the temperature at 1 in. from the soffit was 1,200 degrees F. or higher at 4 hours. The coarse aggregates in the slabs which did not attain to 1,200 degrees F. were slag, limestone (2), basalt, andesite, coke breeze, broken brick and dolerite (whinstone). The highest temperatures at points near the top of the slabs were attained with concretes having as coarse aggregates siliceous gravel (2), calcareous gravel, coke breeze and quartzite."

Column Tests at the Pittsburgh Laboratories of the Bureau of Standards

These tests were designed to secure information as to the effects of kind of aggregate, the type of reinforcement and the shape of cross-section on the fire resistance and strength of the column at high temperatures. Sixty-two columns were subjected to fire tests while under normal working loads.

"The tests gave widely different results due mainly to the differences in the mineral composition of the aggregates. Aggregates with high quartz, chert or granite content are likely to induce spalling or serious cracking of the concrete when subjected to fire of moderate intensity and duration. On the other hand, concretes made with calcareous aggregates, such as limestone or calcareous gravel, suffer few

RESULTS OF CONDUCTIVITY TESTS BY THE BRITISH FIRE PREVENTION COMMITTEE

	Number of Samples Tested	Kind of Coarse Aggregate	Kind of Fine Aggregate	Mix	Order of Merit for 1-in. Protection*	Order of Merit for 2-in. Protection**
Natural Aggregates	5	Limestone	Sand	1:2:4	100	100
	4	Whinstone Traprock	Sand	1:2:4	89	95
	2	Basalt	Sand	1:2:4	84	99
	6	Sandstone	Sand	1:2:4	83	96
	3	Granite	Sand	1:2:4	69	90
	2	Irish Pit Pebble	Sand	1:2:4	67	66
	3	Gravel	Sand	1:2:4	66	87
Artificial Aggregates	1	Pan Breeze	Fine Pan Breeze	1:2:4	91	88
	2	Burnt Gault Clay	Sand	1:2:4	88	121
	3	Slag	Sand	1:2:4	81	81
	2	None	Fine Coke Breeze	1:5	78	108
	4	Brick	Sand	1:2:4	73	96
	3	Coke Breeze	Sand	1:2:4	72	82
	3	Clinker	Sand	1:2:4	61	86
	1	Coke Breeze	Fine Coke Breeze	1:2:4	29	53

* Based on the time required for concrete to attain 1000° F. at one inch from soffit of slab.
** Based on the relative temperatures attained at the end of 4 hours. In each case limestone concrete considered as 100 as an arbitrary point on the scale.

visible effects even when exposed to very severe fires of four hours' duration. Concretes made with trap rock or blast-furnace slag give results intermediate between these.

"The poor showing of the concrete columns made with siliceous aggregates when subjected to fire is due mainly to the expansion characteristic of quartz and other forms of silica and minerals containing them. They spalled and cracked very badly, exposing the reinforcement in most cases to the high temperatures of the furnace. Increasing the thickness of the covering to 2½ in. did not give suitable protection.

"* * * Columns made with concrete having limestone or calcareous gravel aggregates made quite the best showing of all columns having concrete protection. They did not crack or spall extensively, nor did the dehydration of the concrete reach to as great a depth. The limestone near the surface was calcined. Concretes made with these aggregates had better heat insulating qualities than the others.

"Such columns with the proper amount of vertical and lateral reinforcement protected by 1½ in. of concrete outside the steel resist test fires comparable to the most severe fire conditions that may reasonably be expected with almost any building occupancy. * * * "

Tests at the Underwriters Laboratory, Chicago

Fire tests were made on 106 columns and the following are some of the significant results obtained:

"The mineral composition of the aggregates had the most influence on the fire-resistive properties of the concrete. Not only were some of the concretes distinctly better than others but showed greater recovery of strength after exposure to fire.

"With regard to the variations of the fire resistance of the concretes with respect to difference in aggregates used, it might be well to quote from Technologic Paper No. 184, p. 179, 'with a given thickness or size of covering the main cause of variation in results was the difference in the fire resisting properties of concrete made with different aggregates.

" 'In this particular the concrete can be placed in three groups. That giving the most unfavorable results was the concrete made with the Meramec River sand and gravel, a number of large cracks forming early in the tests followed by spalling of large and small pieces of concrete not held by the ties. This sand and gravel consists almost wholly of quartz and chert grains and pebbles, the gravel having a particularly high chert content. Both minerals are forms of silica (SiO_2) the quartz being crystalline and anhydrous, and the chert amorphous, with a variable amount of water in chemical combination. On being heated part of the combined water in chert is liberated, and the consequent vaporization disrupts the pebbles. Other causes of disruption of concrete made with siliceous aggregates are abrupt volume changes, points of which are known to exist for chert as low as 210°C. (410°F.) Quartz has a decided point of abrupt volume change at 573°C. (1063°F.) where it is transformed into Beta quartz and later into the mineral tridymite, the change extending over a considerable temperature range when the heating is rapid. Liquid inclusions contained in

small cavities formed when the rock crystallized from the molten condition, may be the cause of some of the cracking incident with fire exposure.

" 'The middle group includes concrete made with trap rock, granite, sandstone, and hard coal cinder. In tests with trap rock and cinder concrete a small amount of cracking developed during the last part of the fire period, but no spalling of note occurred before failure. In the granite concrete protections, cracking and spalling of the corners outside of the wire ties began in the first 30-min. period and continued during the next hour, after which there was little apparent change before failure. The spalling exposed portions of the flange edges, which to some extent hastened the failure. The average time to failure in tests with sandstone-concrete protections was intermediate between those with trap rock and those with cinders-concrete. The cracking of sandstone concrete after a short fire exposure can be ascribed mainly to the abrupt volume change of the constituent quartz grains as noted above.

" 'Fusion of the trap rock concrete occurred where the tests extended beyond 7 hours, the concrete being affected to a depth of about 1½ in. Flowing of concrete due to fusion, while not general, occasionally formed pockets up to a 2-inch depth. Incipient fusion to about the same depth occurred in the 4-inch granite-concrete protections, although no actual flowing of concrete took place.

" 'The third group comprises protections of Chicago-limestone concrete and Joliet-gravel concrete. The composition of this gravel is similar to that of Chicago limestone, and the fire resisting properties of the concrete made with each compare quite closely. Very little cracking resulted on exposure to fire and their heat-insulating value was increased by the change of the calcium and magnesium carbonates to the corresponding oxides. This process retarded the flow of heat through the region of change and left material of good insulating properties. Immediately after the test the surface of the concrete was firm, but after a few weeks' exposure the hydration of the oxides caused slaking and crumbling of the calcined material. * * * ' "

Résumé

"The lessons that may be drawn from the studies so far made by the Committee are that the fire resistance of concretes depends to a great extent on the kinds of aggregates used. Aggregates, such as the siliceous gravels used in the tests reviewed, result in concretes which are likely to spall rather

FIRE RESISTANCE PERIODS DERIVED FROM THE TEST RESULTS

Type of Column	Protection		Minimum Area of Solid Materials sq. in.	Nominal Thickness of Protection	Fire Resistance Period hrs.
	Material	Details			
Structural Steel	Concrete: sil. Gravel aggregate	Mixture 1:6 tied with steel ties or wire mesh equivalent to not less than No. 5 (B&S) wire on 8-in. pitch.	100	2 in.	1
Structural Steel	ditto	ditto	200	4 in.	2½
Structural Steel	Concrete: granite, sandstone or hard coal cinder aggregate	Mixture 1:6 concrete tied as above.	100	3	2½
Structural Steel	ditto	ditto	140	3	3½
Structural Steel	ditto	ditto	200	4	5
Structural Steel	Concrete: trap rock aggregate	Mixture 1:6 tied as above	100	2	3
Structural Steel	ditto	ditto	140	3	4
Structural Steel	ditto	ditto	200	4	5
Structural Steel	Concrete: limestone or calcareous gravel aggregate	Mixture 1:6 concrete tied as above	100	2	4
Structural Steel	ditto		140	3	
Structural Steel	ditto		200	4	8
Reinforced Concrete	Limestone or calcareous gravel concrete	Mixture 1:6 concrete reinforced with vertical bars and lateral ties or hooping.	220	2	8
Reinforced Concrete	Trap rock concrete	ditto	220	2	5

quickly when exposed to fires. Small percentages of chert or other highly siliceous aggregates mixed with aggregates which do not spall may still cause serious cracking and spalling. Sandstones and granites vary somewhat in affecting the fire resistance of concrete in which they are used as aggregates, but usually the results are slightly better than with the siliceous gravels. Both have the tendency to crack and spall. Hard-coal-cinder concrete does not show this tendency, but transmits heat more readily, therefore, does not give longer protection to the steel and structural concrete. Concrete made from blast furnace slag gives results in fire tests about equal to those of trap rock concrete. Both are decidedly better than concretes having the highly siliceous aggregates. In nearly all tests limestone has been shown to be superior to all the other natural aggregates in its fire-resisting qualities. There is little or no tendency for the limestone concrete to spall or crack and its insulating value is generally greater. In fires of long duration the limestone aggregate near the surface becomes calcined and in some cases necessitates more surface repair to the protective covering than where trap rock is used, but these cases are the exception rather than the rule. So far as tests have been made it has been found that for rocks of a given mineral composition those of coarsely crystalline structure are not as resistant to fire as those of fine structure. Broken bricks or burnt clay aggregates give favorable results in strength and fire-resistive properties."

In 1921 the Associated Factory Mutual Fire Insurance Companies ran an extensive series of tests on all types of concrete building columns. These columns had an effective length of 12 ft. 8 in. and were designed for a working load of 100,000 lb. All mixes were 1:2:4 with an average strength of 1520 psi at 29 days. The columns were placed in a fire chamber and the temperature was gradually raised until at 8 hr. a maximum of 2300°F. was reached, loads being maintained continuously on the columns during the test. The following are the test results, together with quotations from the report of these tests:

(I) *Unprotected Steel Column*
Failed in from 11 to 19 minutes.

(II) *Steel Columns protected by 2 inches of concrete failed as follows:*

Limestone Concrete	6 hr. 34 min. to 7 hr. 16 min.
Trap Rock	4 hr. 38 min.
Sandstone	4 hr. 12 min.
Cinders	3 hr. 44 min.
Siliceous Gravel	1 hr. 47 min.

(III) *When steel columns were protected by 4 inches of concrete the results were:*

Limestone Concrete	8 hr. 8 min.
Granite	7 hr. 58 min.
Trap Rock	7 hr. 35 min.
Siliceous Gravel	3 hr. 41 min.

(IV) *Reinforced Concrete Columns*

Limestone Concrete	8 hr. 6 min. to 8 hr. 40 min.
Trap Rock	7 hr. 23 min. to 7 hr. 57 min.

Siliceous Gravel—no test made

(V) *Tests made of columns constructed so that each of three sections had a different type of aggregate reacted as follows:*

1. Steel Columns Protected by 2 inches of concrete.

1a—(a) Limestone, (b) Trap Rock, (c) Lime Gravel } Concrete pitted but stood up well.

1b—(a) Trap Rock, (b) Granite, (c) Limestone } No cracking, but under hosing its center section washed away.

2. Reinforced Concrete Columns

2a—(a) Limestone, (b) Siliceous Gravel, (c) Limestone Gravel } Considerable cracking in middle section and when exposed to water, washed away.

2b—(a) Trap Rock, (b) Siliceous Gravel, (c) Granite } General buckling and spalling of center section which washed away when exposed to hose.

(I) *Unprotected Steel Columns—Fire Resistance Index 2*

(II) *Protected Steel Columns*

(a) 2 inch concrete—Fire Resistance Index 15 to 55
(b) 4 inch concrete—Fire Resistance Index 31 to 100
Best results obtained with limestone concrete.

(III) *Reinforced Concrete Columns*

If mix is 1 part cement to 6 parts of aggregate it is equivalent to structural steel columns with four inches of concrete protection.

All reinforcement must have a minimum of two inches of concrete.

(a) Limestone Concrete—Fire Resistance Index 100
(b) Trap Rock Concrete—Fire Resistance Index 65
(c) Gravel —Fire Resistance Index 30

(IV) *Effect of Kind of Aggregate*

The kind of aggregate used in making concrete can be divided into three classes according to its fire resistive qualities. They are as follows:

Type	Fire Resistance Index	
Limestone and Limestone Gravel	2 inch—55	4 inch—100
Trap Rock, Granite, Sandstone, and Hard Coal Cinders	2 inch—34	4 inch— 64
Siliceous Gravel or other siliceous material	2 inch—15	4 inch— 31

Siliceous aggregate is not recommended for a covering concrete when possible to obtain other kinds of aggregates, and should NEVER be used for partly protected columns.

Fire Resistance Periods of Columns

Two Inch Concrete		
Siliceous Gravel	1	hour
Trap Rock, Granite, Sandstone, Cinders	2½	hours
Limestone .	4	hours
Four Inch Concrete		
Siliceous Gravel	2½	hours
Trap Rock, Granite, Sandstone, Cinders	5	hours
Limestone Aggregate	8	hours

(Note particularly that while limestone was given an index rating of 100, siliceous gravel received only 30 as an index. As a fire resistive aggregate, siliceous gravel is only 1/3 as good as limestone.)

It appears evident from this particular set of tests that the fire resistant qualities of siliceous materials are low indeed. But is there other creditable evidence to be found in support of these findings of the Associated Factory Mutual Fire Insurance Companies? Decidedly so!

The Portland Cement Association in their bulletin No. ST. 32, dated May 1938, has the following to say on this subject:

> *"In general, limestone aggregates give better results than siliceous materials. This is verified also in fire tests. Limestone aggregates also produce less spalling than siliceous aggregates upon exposure to intense heat."*

Experience from Severe Fires

Laboratory tests are rather consistent in telling a definite story regarding the behavior of different aggregates, but even more convincing to some may be the effects produced by severe fires in actual concrete buildings.

The Mullen & Buckley Warehouse fire at Far Rockaway, New York, serves as one good illustration, because it was investigated by a special committee appointed by the American Concrete Institute whose report of the findings is published for review and study to those interested in fire resistance of concrete. This structure was seriously damaged by the fire and the investigating committee observed that the excessive spalling of the concrete was in large measure due to the use of coarse aggregate which contained a large percentage of quartz. Full details will be found in the American Concrete Proceedings for 1921.

During the winter of 1941-1942 a fire in the Erie Railroad Warehouse at Jersey City caused considerable damage to the building. The Supervising Engineer of the New York Board of Fire Underwriters who inspected the structure after the fire reported that: "The serious damage caused appears to be due largely to the materials in the composition of the concrete used in its construction, especially the coarse aggregate." This aggregate was gravel, apparently of a type common to the New York area. Previous fires involving reinforced concrete buildings using such gravel as the coarse aggregate have shown that the damage is entirely out of proportion to the severity of the fire. Contrast this with reports of other fires in which concrete buildings were involved. In 1914 a fire broke out in the Thompson & Norris paper factory in Brooklyn. This was a 12-story building in which trap rock was used in the concrete. It was two hours after the fire started before the flames had been wholly extinguished. The damage was confined to the stock, with little or no damage to the building.

The fire-resisting qualities of reinforced concrete using trap rock coarse aggregate were again demonstrated in the Salem, Massachusetts, fire of 1914. The burned area was something more than 250 acres and the total loss was $14,000,000. Practically everything in the path of the fire was swept away except a four-story reinforced concrete storehouse, property of the Naumkeag Steam Cotton Company, which suffered very little damage. Investigation as to the composition of the concrete revealed that trap rock was used as the coarse aggregate.

Thus, not only laboratory fire tests made under controlled conditions, but also the results of actual fires show that the fire resistance of concrete differs due largely to the difference in spalling under intense heat and this is influenced very largely by the coarse aggregates used.

Fire Resistance Ratings

Obviously, not only the intensity of a fire, but also its duration must have an effect on the damage to concrete for the simple reason that time is required to heat concrete to a temperature at which serious thermal expansion or serious spalling may take place. It must be obvious that the kind and amount of combustible material and the promptness and efficiency of fire-fighting methods will control the period of time during which the concrete is subjected to intense heat. The factors which influence the intensity and duration of the fire are variables which for the most part are unpredictable and in line with good engineering practice it seems wise to anticipate the worst fire destruction hazard which is likely to exist in the particular kind of building being considered. For illustration, the possibilities of severe fire destruction are much worse in a warehouse containing inflammable oils and paints than they would be in an office building containing some inflammable furniture and office supplies. This question of relative fire hazard is taken care of in a somewhat arbitrary and necessarily somewhat inexact method by assuming certain maximum fire resist-

ance periods which the building should be designed to withstand and on the basis of laboratory tests and service behavior to require definite thicknesses of protection of the structural or reinforcing steel applicable to the particular time rating assumed.

The National Bureau of Standards Handbook No. 19, "Manual of Fire—Loss Prevention of the Federal Fire Council" shows the "Equivalent durations for fires in fire-resistive buildings with calorific value of combustibles assumed in the range for wood and paper." Ten pounds of wood or paper per square foot of floor area is considered equivalent to a fire of one hour duration; 20 lb.—2 hr.; 30 lb.—3 hr.; and 40 lb.—4 hr. 30 min. duration. Cotton, wool, silk, straw, grain, sugar and similar organic materials are considered as equivalent in calorific value to wood and paper. On the other hand, oils, fats, waxes, pitch, alcohol and similar materials have higher calorific values and their weight should be multiplied by two to determine the combustible contents in terms of paper and wood when calculating the fire duration period. Thus, for any type of building and with a calculated assumption as to contents, the fire duration period which should be required may be determined. The problem of determining fire-duration periods, however, is not always as simple as the preceding method sounds, for hazardous exterior circumstances can have an important effect.

Concrete Thickness Requirements

All building codes are not entirely in agreement regarding the amount of concrete protection required for the different concrete aggregates and the different times of exposure, but most of them do recognize that there is a difference in fire protection afforded by different classes of aggregates. The following method of differentiating between aggregates depending upon their fire resistances is typical and illustrates the present trend. It is taken from the Building Code recommended by the National Board of Fire Underwriters.

FIRE RESISTANCE RATINGS OF COLUMNS PROTECTION

Ratings Based on Standard[a] Fire Tests

Type	Details of Protection	Minimum Thickness[l] Inches for Rating of			
		4 hrs.	3 hrs.	2 hrs.	1 hr.
Steel 6x6 in. or larger[m], except as otherwise noted.	Concrete, coarse aggregate limestone or calcareous gravel[n]; fill of same material (26)	2	—	—	—
	Concrete, coarse aggregate trap rock; fill of same material; steel wire ties[p]; columns 8x8 in. or larger (26)	2	—	—	—
	Concrete, coarse aggregate granite, sandstone or cinders[o]; fill of same material; steel wire ties[p]; (26)	—	2	—	—
	Concrete, coarse aggregate siliceous[x] gravel; fill of same material; steel wire ties[p]; (26)	—	—	—	2
	Concrete block, hollow, cinder; fill of cinder concrete slabs and mortar with 1¼ in. mortar between column and blocks; ¾ in. gypsum and sand plaster on outside. (29)	3	—	—	—

Apparently only limestone, calcareous (limestone) gravel and trap rock are recognized as suitable for the worst condition requiring a 4-hour rating; granite, sandstone and cinders are permitted for a 3-hour fire rating, while siliceous gravel is considered suitable only for a 1-hour rating, the minimum thickness of protection being 2 inches in all cases.

For reinforced concrete this same Code specifies the following:

Type	Details of Protection	Minimum Thickness[1] Inches for Rating of			
		4 hrs.	3 hrs.	2 hrs.	1 hr.
Reinforced Concrete aa	Concrete, coarse aggregate limestone, calcareous[n] gravel, trap rock or blast furnace slag (27)	1½	—	—	—
	Concrete, coarse aggregate granite, sandstone, or siliceous gravel[s] (27)	2½	1½	—	—
	Concrete, coarse aggregate granite, sandstone or siliceous gravel[s]; with light, 2 in. mesh expanded metal centrally located in the protective covering (27)	1½	—	—	—
	Concrete ½ in. coarse aggregate granite, sandstone or siliceous gravel[s], covered with 1 in. 1:2½ (by volume) Portland cement and sand or gypsum and sand plaster, with admixture of not over ½ part lime; surface of column backed or column cast in metal lath form (27)	1½	—	—	—

Notes: a "Standard" tests refer to tests made in substantial accord with the "Standard Methods of Fire Tests of Building Construction and Materials", A. S. T. M. C19-41 (See Appendix B.)

1 Thicknesses given are of the protection around the outside of the steel column, beam, girder, or truss, or cast iron column and outside of the reinforcing steel in reinforced concrete columns, beams, girders and trusses. They do not include thickness of plaster except where the protection consists only of metal lath and plaster.

m The fire resistance of columns is proportional to the area of solid material in the cross section of the column—the larger the column the greater the fire resistance, for a given thickness of protection around the structural or reinforcing steel. The column dimensions given are the outer cross sectional dimensions of the steel or cast iron columns and the outside cross sectional dimensions of reinforced concrete columns. Columns smaller than those listed may require greater thicknesses of protection for the same degree of of fire resistance.

n Gravel contained not more than 10 per cent quartz, chert and flint.

o Cinders contained not over 10 per cent unburned coal and not over 5 per cent ash.

p Wire ties consisted of No. 5 B & S gage (0.18 in. diam.) steel wire wound spirally around the steel column on a pitch of 8 in.

s The aggregates used contained 60 per cent or more of quartz, chert or granite.

x Siliceous gravel contained 100 per cent chert and quartz.

aa These ratings apply to columns with standard ties or spirals and to columns without spirals if designed on the basis that the protective concrete covering carries no load. If the design load is based on the gross column area and the column does not have adequate ties or spirals the actual fire resistance will be considerably lower.

References: (26) "Fire Tests of Building Columns", a joint report of Underwriters' Laboratories, Inc., the Associated Factory Mutual Fire Insurance Companies and the National Bureau of Standards, 1920.

(27) "Fire Resistance of Concrete Columns", National Bureau of Standards Technologic Paper No. 272, 1925.

(29) "Fire Test of a Building Column", National Bureau of Standards Technical News Bulletin No. 246, Oct. 1937.

Here, limestone, calcareous (limestone) gravel, trap rock and blast furnace slag are considered suitable for a 4-hour fire with only 1½ inch of concrete covering over the reinforcing steel; granite, sandstone and siliceous gravel are considered as suitable for a 4-hour fire if 2½ inches instead of 1½ inch thick, and if made only 1½ inch thick, these aggregates are rated only 3-hour materials, but they are considered 4-hour materials if used with the addition of expanded metal in the protective covering to assist in retarding spalling.

The preceding requirements, quoted from the Building Code Recommended by the National Board of Fire Underwriters, 1943 Edition, are typical of the way a number of local building codes recognize the variation in fire protective values of different coarse aggregates. Unfortunately some local codes contain no recognition of the differences in aggregates. That is an oversight which should be corrected at the earliest opportunity. Such national authorities as the U. S. Department of Commerce Building Code Committee, The National Board of Fire Underwriters, The Joint Committee on Concrete and Reinforced Concrete and the American Concrete Institute Building Code Committee, all agreeing in principle if not in every detail regarding the variable fire protection of concrete due to aggregates, should not be ignored.

In conclusion, it can be said that seldom has the weight of evidence from tests and experience been more conclusive than that concerning the effect of aggregates on the fire resistance of concrete. Fine-grained igneous rocks, limestone, slag, cinders containing a minimum of unburned coal and most light weight aggregates rate high in their resistance to fire while, at the other end of the scale, are the highly siliceous or chert gravels which seem invariably to cause early and serious spalling which exposes the underlying steel to dangerously high temperature. It should go without saying that facts such as these require recognition by building codes everywhere.

Building codes should not become more lenient in their treatment of fire resistance and in their consideration of concrete in general. On the contrary, in the interest of public safety they should lean toward more rigid and more exacting requirements.

TABLE 2.

COEFFICIENTS OF THERMAL EXPANSION OF AMERICAN ROCKS [1]

No.	Name of rock specimen	Location Found	Coefficient of Thermal Expansion, Room Temp. to 212°F.
		IGNEOUS ROCKS	
	Rhyolite-Granite Series		
1	Felsitic Rhyolite	Mojave, Calif.	41×10^{-7} (1)
2	Rhyolite Breccia	Animas Forks, Colo.	45
3	Granite Porphyry	Winchester, Mass.	34
4	Binary Granite	Concord, N. H.	49
5	Biotite Granite	Picton Is., N. Y.	36
6	Biotite Granite	Cripple Creek, Colo.	19
7	Biotite Granite	Westerly, R. I.	47
8	Biotite Granite	Westerly, R. I.	(2)
9	Biotite Granite	Barre, Vt.	52
10	Biotite Granite	Llano Co., Texas	39
11	Biotite Granite	Spring Creek, Colo.	
12	Biotite Granite (Granitite)	Woodbury, Vt.	38
13	Biotite Muscovite Granite	Georgetown, Colo.	66
14	Biotite Muscovite Granite	Near Peekskill, N. Y.	41
15	Biotite Muscovite Granite	Mount Airy, N. C.	45
16	Alkali Granite	Quincy, Mass.	29
17	Alkali Granite	Quincy, Mass	58
18	Aplite	Boulder Co., Colo.	50
19	Flourite Granite	Clinton Co., N. Y.	56
20	Spring Creek Granite	Cripple Creek, Colo.	37
21	Hornblende Granite	Fredericksburg, Texas	37
22	Amphibole Granite	Hurricane Is., Me.	60
	Trachyte-Syenite Series		
23	Quartz Syenite	Ticonderoga, N. Y.	37
	Dacite-Quartz-Diorite Series		
24	Granodiorite	St. Cloud, Minn.	42
25	Dacite	San Luis Obispo Co., Calif.	28
	Andesite-Diorite Series		
26	Hornblende Andesite	Mount Shasta, Calif.	23
27	Andesite Porphyry	Newton, Mass.	25
28	Andesite Porphyry	Boulder Co., Colo.	39
29	Andesite	San Juan Co., Colo.	57
30	Orbicular Gabbro Diorite	Davis Co., N. C.	
	Basalt-Gabbro Series		
31	Hornblende Basalt	Chaffee Co., Colo.	26
32	Olivine Basalt	Jefferson Co., Colo.	22
33	Olivine Basalt	Mt. St. Helens, Wash.	33
34	Basalt Porphyry	Lake County, Ore.	26
35	Dolerite Porphyry	Cape Ann, Mass.	35
36	Fine-Grained Diabase	Somerset Co., N. J.	35
37	Diabase	Somerville, Mass.	31
38	Greenstone	Winton, Minn.	50
39	Bytownite Gabbro	Duluth, Minn.	30
40	Orthoclase-Quartz Gabbro	Wichita Mts., Okla.	20×10^{-7}
41	Orthoclase Gabbro	Duluth, Minn.	Lost

[1] From "Thermal Expansion of Rocks," by John H. Griffith, Bulletin 128, Iowa Experiment Station.

(*Continued on Page 24*)

Table 2 (Continued)

	SEDIMENTARY ROCKS		
	Breccias and Conglomerates		
42	Syenite Breccia	Boulder County, Colo.	$30x10^{-7}$
43	Chert Breccia	Cherokee County, Kan.	67
44	Limestone Breccia	Boulder County, Colo.	52
	Sandstones		
45	Argillaceous Sandstone	Portageville, N. Y.	47
46	Red (Ferruginous) Sandstone	Potsdam, N. Y.	$57x10^{-7}$
47	Gray Sandstone (Berea Grit)	Berea, Ohio	$51x10^{-7}$
48	Gray Sandstone	Keeseville, N. Y.	37
49	Sandstone	Jordan, Minn.	56
50	Sandstone	Medina, N. Y.	63
51	Brownstone	Somerset Co., N. J.	55
52	Calcareous Sandstone	Socorro, N. M.	65
	Limestones and Dolomites		
53	Coquina	St. Augustine, Fla.	
54	Limestone	Boulder Co.,Colo.	40
55	Limestone	Onondaga Co., N. Y.	24
56	Coral Limestone	LeRoy, N. Y.	28
57	Coral Limestone	Jeffersonville, Ind.	49
58	Gray Limestone	Valcour Is., N. Y.	17
59	Gray Limestone	Ruth, Nev.	48
60	Encrinal Limestone	Lockport, N. Y.	68
61	Encrinal Limestone	Trenton Falls, N. Y.	56
62	Argillaceous Limestone	Rochester, N. Y.	51
63	Pale Gray Limestone	Concrete, Colo.	24
64	Chert Limestone	Buffalo, N. Y.	
65	Oolitic Limestone	Batesville, Ark.	31
66	Oolitic Limestone	Bedford, Ind.	43
67	Black Oolite (Fossiliferous)	Milton, Pa.	30
68	Dolomitic Limestone	Gouverneur, N. Y.	58
69	Dolomitic Limestone	Rochester, N. Y.	58
70	Birdseye Limestone	Watertown, N. Y.	37
71	Chocolate "Tenn. Marble"	Near Knoxville, Tenn.	53
	Siliceous Rocks		
72	Diatomaceous Silica	Santa Barbara, Calif.	15
73	Chert	Joplin, Mo.	64
	Chemical Precipitates		
74	Travertine (onyx marble)	Suisun, Calif.	62
75	Travertine (onyx marble)	Great Salt Lake, Utah	$44x10^{-7}$
	METAMORPHIC ROCKS		
	Gneisses and Crystalline Schists		
76	Biotite Gneiss	Uxbridge, Mass.	$34x10^{-7}$
77	Biotite Gneiss	Baltimore, Md.	44
78	Biotite Gneiss	Cripple Creek, Colo.	13
79	Granitoid Gneiss	Salisbury, N. C.	42
80	Gabbro Gneiss	Albemarle Co, Va.	43
	Quartzites and Slates		
81	Baraboo Quartzite	Abelman, Wis.	61
82	Quartzite	Dell Rapids, S. D.	60
83	Quartzite	Sioux Falls, S. D.	
84	Red Slate	Granville, N. Y.	49
85	Gray Slate	Bangor, Pa.	45
86	Green Slate	Pawlet, Vt.	49
87	Catlinite	Pipestone Co., Minn.	35
	Crystalline Limestones and Dolomites		
88	Crystalline Limestone	Rutland, Vt.	27
89	Napoleon Gray Marble	Phenix, Mo.	51
90	White (Yule) Marble	Marble, Colo.	38
91	Dolomitic Marble	Lee, Mass.	50
92	Pink and Gray Banded Marble	Hewitts, N. C.	38
93	French Gray Marble	Plattsburg, N. Y.	48
94	St. Lawrence Marble	Gouverneur, N. Y.	45
95	Pittsford Valley Marble	Florence, Vt.	45
96	Variegated Dolomitic Marble	Swanton, Vt.	44
97	Verd Antique	Pyrenees Mts.,France	$34x10^{-7}$

(1) 10^{-7} is $1/10^{7} = \frac{1}{10,000,000}$ or 0.0000001;
hence $41x10^{-7} = 0.0000041$

(2) Absence of a value indicates loss or breakage of specimen.

Building officials have the responsibility of safeguarding the lives and property of the citizens in their vicinity. Theirs is a serious responsibility and their effectiveness as guardians of public safety begins with and is dependent upon the book of rules under which they work, namely, their local Building Code. Let that code be reasonable, but let it require the best that can be obtained. Safety surely takes precedence over unwarranted economy.

TABLE 3

AVERAGE COEFFICIENTS OF LINEAR THERMAL EXPANSION OF ROCKS FROM VARIOUS SOURCES [1]
(RANGE FROM 32°F. TO 212°F.)

Coefficients of thermal expansion (multiply numerals by 10^{-7})									
Chert	Quartzite	Granite	Limestone	Sandstone	Slate	Marble	Basalt	Porphyry	Authority
65	59	44	44	54	45	45	27	30	Griffith (author)
		40	45	55	58	45			Merriman [3]
		46		53		65			Hodgman [4]
		36	28	52	52	38			U. S. Arsenal [5]
		45	36			55			Marks [6]
		48		95		57			Merrill [7]

(3) Merriman, Mansfield, ed. "American Civil Engineers' Pocket Book." 1st ed. John Wiley & Sons, Inc., New York, 1911
(4) Hodgman, C. D., ed. "Handbook of Chemistry and Physics." 19th ed. p. 1159. Chemical Rubber Pub. Co., Cleveland, Ohio, 1934.
(5) Withey, M. O., and James Aston, "Johnson's Materials of Construction." 7th ed., p. 614 John Wiley and Sons, New York, 1930.
(6) Marks, Lionel S., ed. "Mechanical Engineers' Handbook." 3rd ed. p. 305. McGraw-Hill Book Co., Inc., New York, 1930.
(7) Merrill, G. P., "Stones for Building and Decoration." 3rd ed. John Wiley and Sons, Inc., New York, 1910.

LIST OF REFERENCES TO USEFUL DATA ON FIRE-RESISTANT PROPERTIES OF CONCRETE

(The following abbreviations are used in the references.)

P.C.A.—Portland Cement Association, 33 W. Grand Ave., Chicago 10, Ill.
A.C.I.—American Concrete Institute, 7400 Second Blvd., Detroit 2, Mich.
A.F.M.—Associated Factory Mutual Fire Insurance Companies, 184 High St., Boston, Mass.
A.S.A.—American Standards Association, 70 E. 45th St., New York City 17.
A.S.T.M.—American Society for Testing Materials, 260 S. Broad St., Philadelphia 2, Pa.
B.F.P.C.—British Fire Prevention Committee, Care of the National Fire Brigades Association, 8 Waterloo Place, Pall Mall, London SW 1, England.
B.S.—National Bureau of Standards, Washington 25, D. C.
N.B.F.U.—National Board of Fire Underwriters, 85 John St., New York City.
N.F.P.A.—National Fire Protection Association, 60 Battery March St., Boston, Mass.
U.L.—Underwriters' Laboratories, 207 E. Ohio Street, Chicago, Ill.

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1 From "Thermal Expansion of Rocks," by John H. Griffith, Bulletin 128, Iowa Experiment Station.

Stable Pavements with Soft Asphalt[1]

By RAYMOND HARSCH

Member, Engineering & Development Committee, Asphalt Institute, Pacific Coast Division

• Aggregates play a most important role in creating stability in an asphalt paving mixture. The present article shows the advantage of using crushed, rough surfaced, well-graded particles. With such aggregates, highly stable mixes are secured despite the use of very soft asphalt, while good stability may be impossible with round, smooth, poorly graded particles even when using a very hard asphaltic cement.

IT IS a hot midsummer day in the office of the "Any Oil Company" when the telephone in the Asphalt Department rings and the manager answers. A voice from the other end of the line says, "This is the Paving Superintendent for the ABC Paving Company, and something is wrong with that last car of asphalt you shipped." "What seems to be wrong?" asks the manager. Superintendent—"It is too soft. It acts like road oil and the pavement won't set up. I ordered 85-100 paving asphalt and this stuff must be over 200."

The above conversation is typical of a half dozen or more which may occur during a summer construction season between an asphalt producer and his customers. Following such a complaint, it is often customary for the asphalt supplier to obtain field samples of the asphalt for laboratory check testing and also of the paving mixture which caused the complaint in order that it may be tested for asphalt content, gradation of aggregates and stability of the mix.

It is the purpose of this discussion to describe some of the conditions revealed by these complaint investigations and to show that the asphalt is very seldom responsible for the instability of the pavements except when used in excessive quantities. In the first place, there are very few instances where tests of the field sample taken from the asphalt shipment do not show the asphalt to comply with the specifications and be of proper grade, as responsible suppliers do not permit the shipment of asphalt prior to laboratory testing. The problem then becomes one of analyzing the combination of asphalt and mineral aggregates from samples taken after the pavement is placed and compacted on the street. In this connection it should be remembered that the asphalt represents only 5 to 7 per cent by weight of an asphaltic concrete mixture and should therefore not be required to overcome all the deficiencies of the other 93 to 95 per cent of the mix. But that is what is often done.

It is true that the asphalt acts as the binder or cohesive medium but it is also true that asphalt acts as a lubricant, particularly when it becomes soft at elevated temperatures. As the complaints on stability of pavement invariably arise during summer temperatures, at which time asphalt pavements reach a temperature of 140°F. or higher, practically all steam refined asphalts of the normally used grades attain temperatures above their softening point. The following table shows how little difference there is in the softening points of the several grades of paving from the same source.

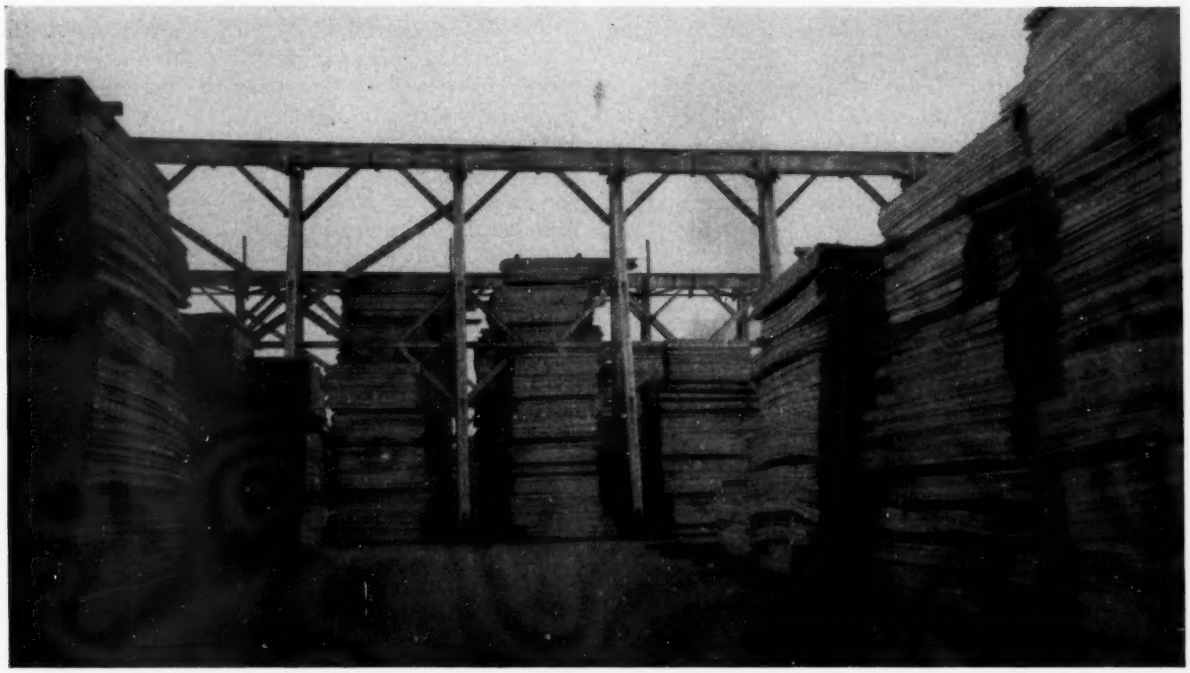
Penetration at 77°F.	Softening Point, °F.
52	120
66	117
80	114
97	112
114	109
143	106
183	102

The penetration of all of the above grades is 300+ at 104°F. Temperatures of only 2° or 3°F. above the standard testing temperature of 77°F. would give penetration test values that would place each asphalt in the next softer grade.

The flow of paving asphalt when an open end barrel of it is placed on its side is a common sight even at cool temperatures; therefore at summer pavement temperatures these grades of paving asphalt furnish little resistance to plastic shear or to the tendency of the mineral aggregate particles to slide upon each other when subjected to pressures.

Ignoring any slight contribution the asphaltic binder may make in resisting plastic shear at summer pavement temperatures, the entire resistance to deformation of the paving mixture by traffic loads must be obtained from the mineral aggregate. And that opens up the subject of stability of mineral ag-

[1] Reprinted from The Asphalt Forum. First Quarter—1946.



Supported on 8-inch by 16-inch sleepers, piles of green, heavy lumber 28 feet high have stood for months on pavements designed in accordance with the principles set forth in this article.

gregates. An analysis of an asphaltic mixture showing low stability usually reveals one or more of the following conditions present:

1. The asphalt content is in excess of the void space in the mineral aggregates. (This appears least often.)
2. The mineral has a predominance of one size particle, particularly of an intermediate size.
3. The coarse aggregate is essentially round water-worn, highly polished gravel.
4. The sand portion is in excess of that required to fill the voids in the coarse aggregate and has a predominance of intermediate sizes of hard, smooth grains lacking in fractions passing 200 mesh screen.
5. There has been insufficient compaction to put the mineral particles in close contact.

A pavement was constructed during the past summer in which practically all of the above conditions

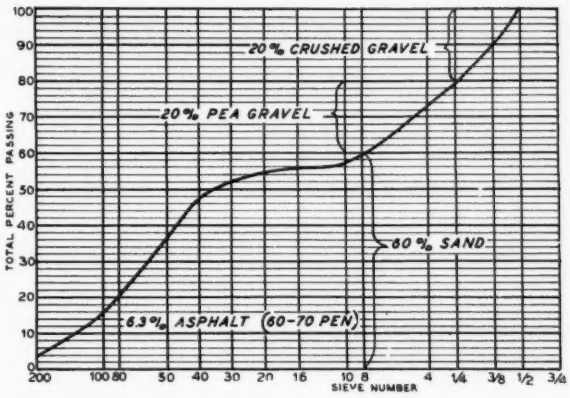


FIGURE 1.

prevailed, resulting in a gradation curve illustrated in Figure 1. To arrive at this combination of conditions, all of which favor instability, the contractor incorporated into his mixture the following materials:

20% of ½" - ¼" fully crushed gravel (a high stability aggregate);

20% of ¼" - 10 mesh round pea gravel completely free of any fractured particles;

60% of a hard-grained, smooth-surfaced sand, 75% of which passed the 40 mesh screen and was retained on the 100 mesh screen, containing very little filler passing 200 mesh.

To the above aggregate was added 6.3% of low-penetration asphalt by weight which was from 1 to 2 per cent more than the hard, smooth, non-absorbent surface area of the mineral particles required. Is it any wonder that the small diameter wheels of the motor driven freight handling trucks bogged down to their axles?

All of these factors need not be present to produce instability in a paving mix. Any single factor or combination of factors which lowers the frictional resistance of the mineral aggregate below that required to support the load will result in instability. Aggregate selection and gradation should therefore always be made to insure a stability adequate for the contemplated loading. High stabilities are obtained by using:

1. A crushed aggregate whenever possible.
2. A sand having particles which are angular and preferably with rough surfaces, well graded from coarse to fine.
3. A proportion of sand to coarse aggregate which does not greatly exceed that required to fill the voids in the coarse aggregate.

A discussion of these principles will illustrate their merit.

Crushed Mineral Aggregates

It should only be necessary to compare visually a piece of fully crushed rock with a piece of water-worn, round gravel to notice the factors favoring the crushed aggregate. This is further revealed by the comparative effort needed to force a shovel into piles of crushed rock and round gravel of large sizes and free from sand or fines. Remembering that the stability of an aggregate depends largely upon the frictional resistance of the mineral particles in contact with each other, it is readily seen that the fully crushed rock possesses rough, fractured surfaces which will hold thick films of asphaltic binder and still maintain a high frictional coefficient between the rough surfaces of adjacent crushed rock particles in a mix. The angularity of the crushed aggregate and the fact that the fractured faces are more flat than spherical permit adjacent particles to form larger areas and more points of contact than is obtained with spherical particles. This feature permits the use of a low percentage of fine aggregate (sand) which is the most critical part of the mix in which to develop stability. Round gravel, on the other hand, requires a higher sand content to provide the points of contact necessary to develop frictional resistance. Crushed aggregate, therefore, is less critical in the amount or the gradation of the sand portion, provided there is not an excess of sand which would spread the particles of coarse aggregate apart, thus preventing the contact necessary for high stability. A typical example of the high stability produced with fully crushed rock is illustrated by the penetration macadam pavements which contain no material passing a 10 mesh screen and are very successfully built with (believe it or not) soft asphalt of 200-300 penetration.

Well Graded Sand

Quite often fully crushed rock is not economically obtainable and use must be made of gravel and sand as the mineral aggregate in an asphaltic concrete mix. This does not mean that pavements of inferior stability must necessarily result. It merely means that a greater degree of care is needed in the proportioning of the gravel, sand and asphalt than in the case of crushed rock aggregate.

Enough has been said about the value of crushed material to recommend that whenever possible any oversized gravel should be crushed to produce as large a percentage of fractured faces in the coarse aggregate as possible. The main burden of producing stability in this type of aggregate, however, is placed upon the sand, which if composed of rough,

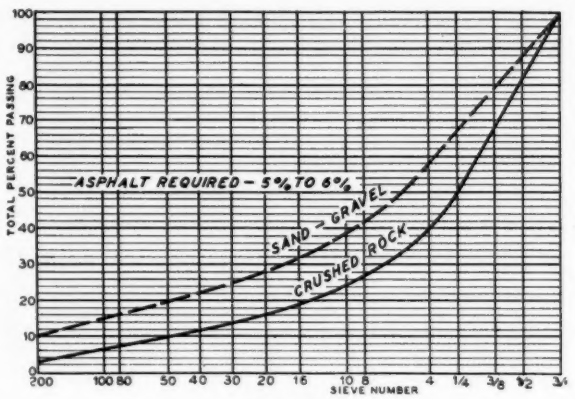
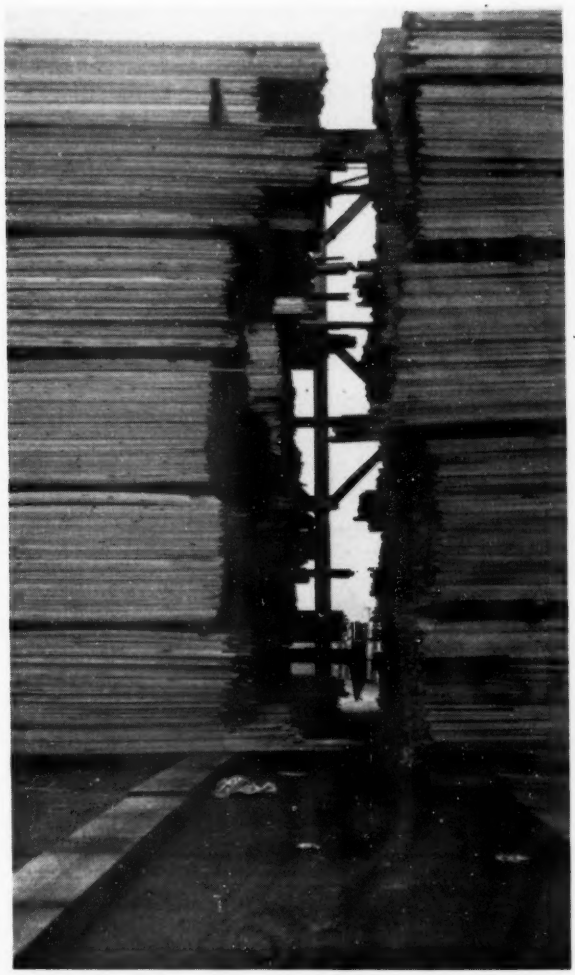
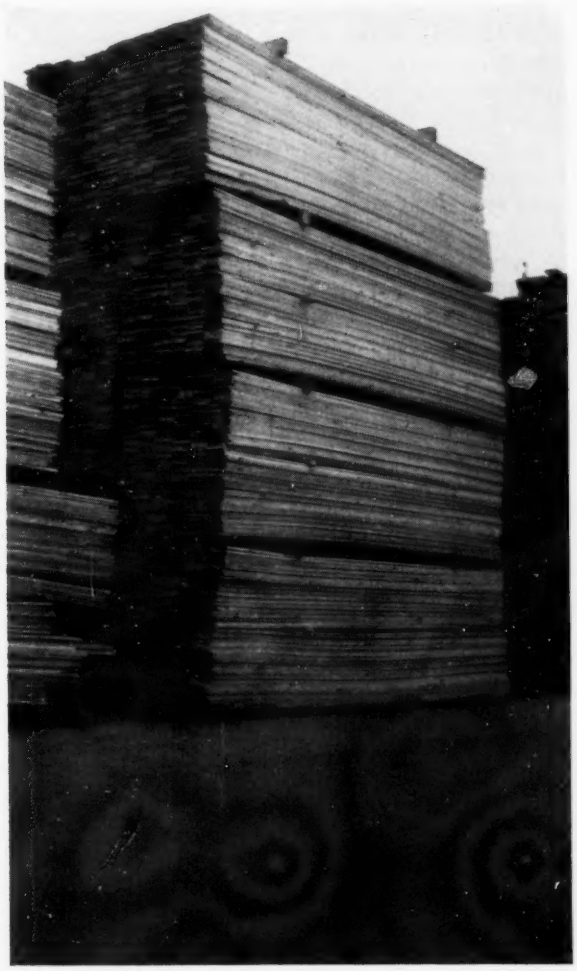


FIGURE 2.

angular grains, graded from coarse to fine, permits the grains to carry a relatively thick film of asphalt and yet retain their rough surfaces in contact. The more numerous the points of contact the greater





These views show in detail the extremely concentrated loadings created by the sleeper-supported piles of lumber illustrated on page 27.

the number of points supplying friction, which is the reason the sand should be well graded, so that the fine particles will fill the interstices of the coarse particles without spreading them apart. This latter action occurs when there is a predominance of particles of intermediate size. Two typical gradings, one having crushed rock aggregate and the other sand-gravel aggregate, are shown in Figure 2. Such gradings will produce the maximum stability for a given surface roughness of the mineral particles. The sand-gravel aggregate usually has smoother surfaces to be coated with asphalt and a lower void content to receive any excess asphalt above that necessary to coat the particle. The quantity of asphalt used, therefore, must be more closely controlled. The crushed rock aggregate, on the other hand, has a high void content and extremely rough surfaces permitting thick films of asphalt and even an excess over that needed to coat the particles without danger of completely filling the voids. Hence the crushed stone aggregate, although having less surface area per unit of weight, will have an oil capacity equal to that of the more dense sand-gravel aggregate.

Thicker films of asphalt permit greater flexibility of the surface without cracking, and greater resistance to oxidation of the asphalt without detracting from stability and better waterproofing of the aggre-

gate. Examples of the stability of such pavements under heavy static loads are illustrated herein. Piles of green lumber 28 feet in height have been supported on 8 by 16 inch sleepers for months without the slightest marking of the pavement. The same type of pavements have supported extremely concentrated static loads in several northwest shipyards with very little marking or indentation.

Soft Asphalt

This article would not be complete without a further discussion of the influences (or the lack of influence) the grade of asphalt has on the stability of the paving. Fifteen or twenty years ago most asphaltic concrete pavements were constructed using 40-50 or 50-60 penetration asphalt cement. A study of the causes for the cracking of asphalt pavement revealed that when asphalt is introduced and mixed with hot mineral aggregates in the paving plant there was often a considerable loss in penetration of the asphalt through oxidation; the resulting low penetration often approached a critical value thought to be responsible for cracking or brittleness of the pavement. Because of this loss of penetration in the mixing plant, a trend developed toward the use of softer asphalt cement of 85-100 and even as soft as 150-200 penetration. These soft asphalts with certain critical mixes caused some difficulty in placing and compacting. It is not the purpose of this discussion to argue the merits of various grades of asphalt for paving mixtures, but to point out that the grade of asphalt is not responsible for the stability or instability of the paving mix. For example, consider the thousands of miles of extremely stable roadmix and plantmix surfaces which have been built with slow curing road oils or medium curing cutbacks. Neither of these binders even approximately approaches the consistency of the softest asphalt cement, and yet the pavements constructed with them usually show higher resistance to static loading than do most of the higher type asphaltic concrete surfaces. The author has often placed a section of compacted slow-curing roadmix or plantmix surfacing on top of a steam radiator for a week at a time without the slightest sign of bending or crumbling. Most asphaltic concrete paving mixes on the other hand, even if made with 40-50 penetration asphalt would tend to flow and bend under its own weight when left on an irregular surface at room temperature.

Again, recalling the many miles of penetration macadam surfaces, it is well known that practically none of these were constructed with asphalt cement having a penetration below 100; most of them were constructed with asphalt of 150 to 300 penetration or more. It is not claimed that there is no difference in the cohesion of the various grades of asphalt, as this is illustrated by the fact that it would be impossible to use a slow curing oil of low viscosity as a binder for large size rock particles. But cohesion should not be confused with friction, which is the important role played by the mineral aggregate in an asphaltic concrete paving. Stability in pavement mixes, therefore, depends upon the aggregate and not upon the grade of asphalt.

Iowa Agricultural Limestone Association Holds Annual Meeting

THE annual meeting of the Iowa Agricultural Limestone Association was held in Des Moines, Iowa, on February 22, 1946, with some thirty producers in attendance.

It was decided to employ a full-time secretary and this responsible post was given to Clint A. Allen. Mr. Allen is excellently qualified for his new position having served with Sargent Brothers, Inc. since 1942 and as part-time secretary of the Association since August 1945.

During the course of the meeting the following were elected to serve on the Board of Directors:

W. F. Sharpe, Dillon, Sharpe & Co., Centerville, Iowa
Paul M. Nauman, Dubuque Stone Products Co., Dubuque, Iowa
Grover C. Hubbell, Douds Quarries, Inc., Douds, Iowa
H. D. Bellamy, Concrete Materials and Construction Co., Cedar Rapids, Iowa
E. I. Sargent, Sargent Bros., Inc., Des Moines, Iowa
E. F. Schildberg, Schildberg Construction Co., Greenfield, Iowa
Vern Schield, Schield Soft Lime Co., Waverly, Iowa
G. B. Clark, Midwest Limestone Company, Gilmore City, Iowa
Don Kaser, Kaser Construction Co., Adel, Iowa

W. F. Sharpe was elected President; H. D. Bellamy, Vice President; and Grover C. Hubbell, Treasurer.

Many matters of interest to the group were discussed and enthusiastic approval evidenced concerning the opportunities for service of the Association during the coming year.

Executive Committee Agricultural Limestone Division Holds Important Meeting

THE first meeting of the Executive Committee of the Agricultural Limestone Division of the National Crushed Stone Association, elected at the Annual Convention of the Division in Cincinnati last January, met at the Edgewater Beach Hotel, Chicago, Ill., on May 10, 1946.

In answer to the roll call the following members of the Committee reported present:

Chairman
S. P. MOORE, Concrete Materials and Construction Co., Cedar Rapids, Iowa.

Northeast Region
PAUL I. DETWILER, New Enterprise Stone and Lime Co., New Enterprise, Pa.

North Central Region
P. E. HEIM, Carbon Limestone Co., Youngstown, Ohio.
E. E. HAAPALA, Zumbrota, Minn.
H. C. KRAUSE, Representing E. J. Krause, Columbia Quarry Co., St. Louis, Mo.

Representing the National Crushed Stone Association
OTHO M. GRAVES, General Crushed Stone Co., Easton, Pa.

In addition there were in attendance Henry A. Huschke, Managing Director, and J. R. Boyd, Secretary-Treasurer, staff members of the Division; and S. A. Phillips of Pit and Quarry and R. S. Torgerson of Rock Products.

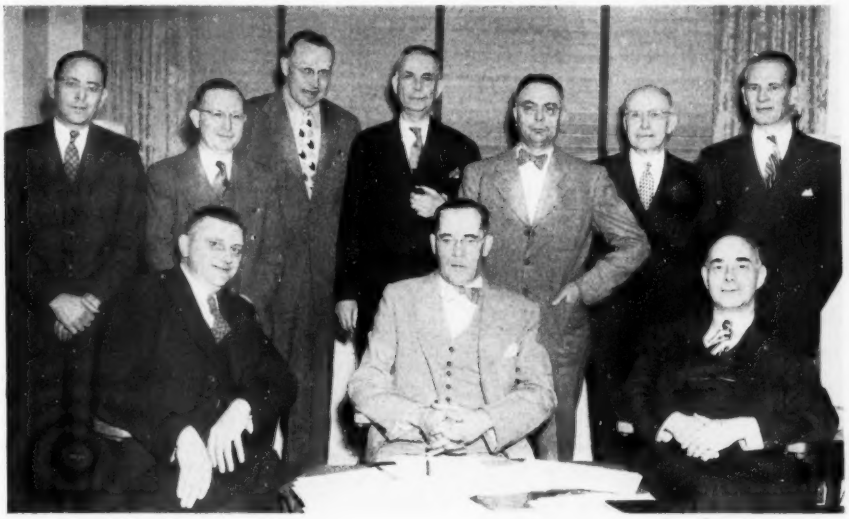
Four members of the Committee were absent, Messrs. Krause, McThenia, Thomas and Willingham, each of whom had expected to attend but were prevented from doing so by circumstances beyond their control. Mr. E. J. Krause, unable to attend because of illness, sent, upon invitation of the Committee, his son Horace C. Krause to represent him.

Many matters of importance to agricultural limestone producers throughout the country were considered at the full day meeting of the Committee, those of broad general importance being briefly summarized in the following.

Reports were received from Henry A. Huschke, Managing Director of the Division, and from its Secretary-Treasurer, J. R. Boyd.

Mr. Huschke reported that the series of five newspaper ads, to be prepared and offered to banks for their use in local papers and designed to extend and promote the use of agricultural limestone, would shortly be given wide circulation among banking circles. It is gratifying to be able to report that up until now (mid June) there is every indication that banks will enthusiastically cooperate in running these advertisements in local papers.

As to the success of the first promotional folder prepared by the Division entitled, "Repair and Rebuild with Limestone and Legumes," Mr. Huschke reported that approximately 200,000 copies had been ordered by member companies for distribution, convincingly illustrating membership approval of this undertaking. Member companies, he also reported, had purchased approximately 112,000 of the so-called "invisible ink post card."



The enthusiastic response accorded release of the first promotional folder convinced the Committee of the desirability of releasing a second promotional piece as soon as circumstances would permit.

Mr. Huschke reported that he had discussed with the Agricultural Chemical Section

of OPA the desirability of amending Revised Maximum Price Regulation 386 to bring it in line with the current wage-price policy of the Administration, that is, to give full and immediate recognition to approved wage increases, whereas currently a producer is prevented from obtaining relief until he has had three months of cost experience after making an authorized wage increase.

The situation with respect to proposed freight rate increases requested by the carriers and docketed as Ex Parte 162, was discussed in detail by Secretary Boyd. He pointed out that, as customary in the past, the National Sand and Gravel Association, the National Slag Association, and the National Crushed Stone Association would jointly participate in a brief protesting the proposed increase in rates on aggregates. The possible desirability of including agricultural limestone in this joint presentation was seriously considered. In view of the fact that aggregates and agricultural limestone have distinctly different uses, the Committee felt it advisable for the Agricultural Limestone Division to present a separate brief in Ex Parte 162 and authorized such action.

It was decided that the Second Annual Convention of the Division should be held at the Edgewater Beach Hotel, Chicago, Ill., on January 30 and 31, 1947, to immediately follow the 30th Annual Convention of the National Crushed Stone Association to be held January 27, 28 and 29, 1947, in view of the many obvious advantages of holding the two meetings at the same hotel during the same week. It was also decided to hold the mid-year meeting of the Board of Directors of the Division at the Hotel New Yorker, New York City, on July 19, 1946, the day immediately following the meeting of the Board of Directors of the National Crushed Stone Association, which is to take place at the same hotel.

Managing Director Huschke briefly outlined a plan for increasing the membership in the Division and on the basis of many helpful suggestions made by members of the Committee present, it was agreed that an intensive effort to increase the Division's membership be undertaken as promptly as possible.

Serious consideration was given by the Committee to the Division's policy with respect to the Conservation Materials Program, particularly in connection with appropriations for the AAA. Chairman Moore was instructed to appoint a committee to develop a statement of policy for the Division with respect to this matter for submission to the Board of Directors at its mid-summer meeting.

Contract Awards for Highway Construction Show Increase

A LARGE increase in the number of contracts awarded by State highway departments in April for work on Federal-aid projects, as compared with contract awards in each of the three preceding months, was reported by the Public Roads Administration of the Federal Works Agency.

During April the State highway departments let 392 contracts for Federal-aid road work that will cost $55,932,506, according to reports received by Public Roads from its field offices.

This was only slightly less than the total of 413 contracts awarded during the first three months of the year at a cost of $71,803,075.

Contract awards from January through April totaled 805, and the total construction cost was $127,735,581. Seventy-eight contract awards for work to cost $14,729,085 were pending on April 30.

Since January 1 State highway departments have rejected 201 bids for Federal-aid road work because the low bid was far above the estimated cost of construction, or for other reasons, without action by the Public Roads Administration. In the same period 36 bids were rejected as a result of Public Roads' refusal to concur in the award of contracts. The refusal of concurrence was prompted by high bidding.

From January 1 through April 30 the number of contracts awarded for all types of highway work under State or Federal supervision, including Federal projects, Federal-aid projects and State-supervised road work financed entirely by State or local government agencies, amounted to 2,299. These contracts were for improvements on 10,217 miles of roadway, at a total cost of $173,037,391.

Gigantic Trailer Carries 600,000 Pounds

A SECRET military operation of the war required the use of a tremendously strong trailer which was designed and constructed in this country. Its 64 wheels transported the heaviest single load ever borne by pneumatic tires. The vehicle was over 39 ft. in length, about 17 ft. wide and by itself, weighed 73 tons. Eight tires made of synthetic rubber, were mounted in eight rows with 39 lbs. air pressure in each. The 600 ton load was transported at a speed of three miles per hour over a stretch of temporary sandy road. The trailer was designed with an excess capacity permitting a 556 ton load if required.

National Airport Bill Authorizes Half Billion Fund

By Walter R. Macatee
Manager, Airport Division A. R. B. A.

PRESIDENT TRUMAN has signed the National Airport Act which was approved by the Senate April 30. The vote in the Senate was 49 to 32. It had already passed the House. An appropriation will be the next step in implementing the measure.

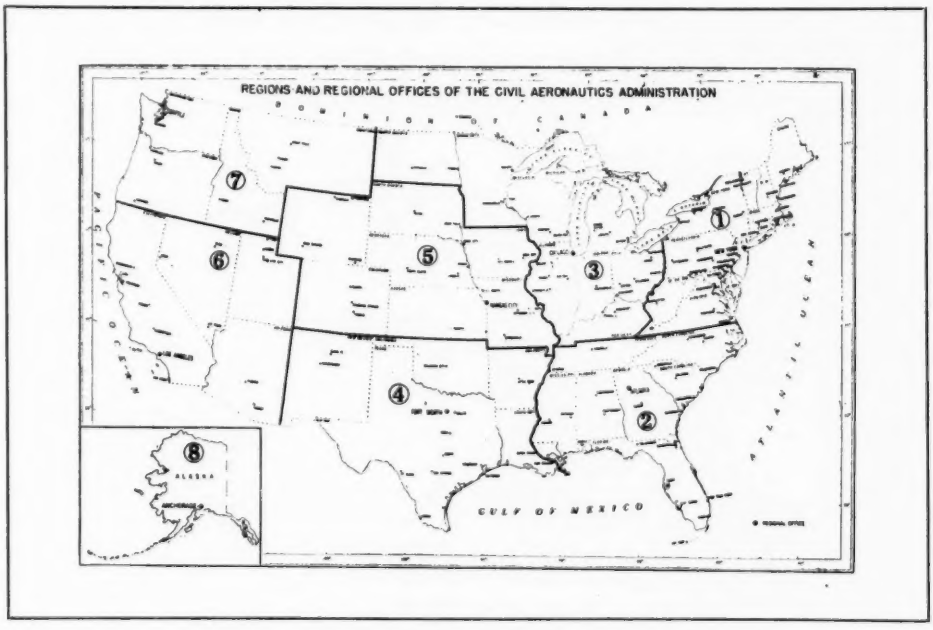
Summarized, the Act provides that any public agency—or two or more acting jointly—may submit an airport project application for Federal-aid; it authorizes $500,000,000 Federal-aid over a 7-year period, not to exceed $100,000,000 in any one year; Federal grants, in general, will be on a fifty-fifty basis for construction. Land and air space easement-costs are allowable for Federal-aid up to 25 percent. Administrative buildings, but not hangars, may participate in Federal-aid for airports.

Apportionments of Federal-aid for airports to the states are made on the basis of area and population of each state in relation to the total population and area of all the states. Seventy-five percent of appropriations shall be apportioned to the states on a population-area formula, and 25 percent of appropriations shall be set up as a discretionary fund for use by the Administrator of CAA for allocation to such projects as he may deem proper, regardless of state lines. Before apportionments are made, 5 percent of appropriations are set aside to cover administrative and planning costs.

The Act provides that municipalities or other public agencies which are prohibited by law of their states may not submit airport development applications. This will have the effect of requiring communities in such states to function through their state agency. Wyoming has recently enacted such a law, and other states could enact similar legislation.

C.A.A. in Charge

Administration of the Act will be under CAA's Administrator, Hon. Theodore P. Wright, and his assistant administrator, Charles B. Donaldson, an old-time friend of the ARBA. Mr. Donaldson's Washington staff, and his regional supervisors of airports and regional managers are now engaged in preparing regulations which will govern in carrying out the act. Normally, airport development project applications will be channelled through CAA's Regional offices, the locations of which are shown in the accompanying map.



No Conflict in Highways and Housing

HIGHWAY construction and the housing program can go along together in 1946 without competition for critical materials, according to a study of six groups of building materials by the Federal Works Agency.

The survey shows that highway building will consume either none or only negligible quantities of the materials in question. Housing needs the following in 1946: 160,000 tons of cast iron soil pipe and fittings; 1,840,000,000 unglazed brick; 250,000,000 feet of gypsum board; 140,000 tons of structural clay tile and 6,500,000 board feet of lumber in addition to millwork and flooring. Highways' only requirements in these materials are practically no soil pipe, about 1 percent of the total production of brick and some 1 percent of total lumber production.

$500,000,000 Federal-Aid for Highways Apportioned

MAJOR GENERAL PHILIP B. FLEMING, Federal Works Administrator, announced May 16 apportionment of the second $500,000,000 of the $1,500,000,000 fund authorized by the Federal-Aid Highway Act of 1944 to assist the States in developing a three-billion dollar highway program.

The funds are for the fiscal year beginning next July 1 and will remain available for obligation to specific projects for two years.

The initial $500,000,000 authorization, for the current fiscal year, became available last October when Congress declared, by resolution, that the war emergency had abated sufficiently to permit State highway departments and the Public Roads Administration to launch the post-war highway program. A third authorization of $500,000,000 will become available on July 1 of next year.

The Act provides that the $500,000,000 authorization for each of the three fiscal years be apportioned as follows:

$225,000,000 for the Federal-aid highway system, apportioned on a basis of one-third in proportion to area, one-third in proportion to population and one-third in proportion to mileage of rural free delivery and star routes.

$150,000,000 for secondary or feeder roads, apportioned on the same formula as the funds for the Federal-aid system except that rural population, which includes the population of less than 2,500, is substituted for total population.

$125,000,000 for the Federal-aid highway system in urban areas, apportioned in proportion to population in urban places of 5,000 or more.

The funds are to be administered in cooperation with the State highway departments according to the usual Federal-aid procedure. Only projects of the classes specified in the legislation and proposed by State highway departments may be considered.

The amounts apportioned to the several States are as follows:

APPORTIONMENT OF FEDERAL-AID HIGHWAY, SECONDARY AND URBAN FUNDS FOR THE FISCAL YEAR 1947

State	Highway ($225,000,000)	Secondary ($150,000,000)	Urban ($125,000,000)	Total
Alabama	$4,722,535	$3,739,291	$1,303,288	$9,765,114
Arizona	3,240,289	2,240,966	262,168	5,743,423
Arkansas	3,868,788	3,112,746	558,221	7,539,755
California	9,017,519	5,161,445	8,122,233	22,301,197
Colorado	4,033,468	2,714,271	933,647	7,681,386
Connecticut	1,395,047	765,980	2,607,495	4,768,522
Delaware	1,096,875	731,250	204,057	2,032,182
Florida	3,236,081	2,167,725	1,599,641	7,003,447
Georgia	5,644,683	4,307,866	1,622,008	11,574,557
Idaho	2,798,389	1,956,701	211,799	4,966,889
Illinois	8,833,305	4,752,492	9,510,696	23,096,493
Indiana	5,403,402	3,623,057	3,065,734	12,092,193
Iowa	5,554,317	3,971,103	1,592,107	11,117,527
Kansas	5,646,272	3,963,849	1,107,219	10,717,340
Kentucky	4,213,497	3,412,080	1,299,529	8,925,106
Louisiana	3,394,999	2,540,348	1,531,578	7,466,925
Maine	1,948,844	1,403,942	560,538	3,913,324
Maryland	1,836,150	1,173,982	1,790,081	4,800,213
Massachusetts	2,942,606	786,455	6,612,615	10,341,676
Michigan	6,833,594	4,133,431	5,682,433	16,649,458
Minnesota	6,043,897	4,163,523	2,206,152	12,413,572
Mississippi	4,041,914	3,334,427	600,115	7,976,456
Missouri	6,664,077	4,565,111	3,151,158	14,380,346
Montana	4,543,707	3,104,425	307,665	7,955,797
Nebraska	4,470,027	3,155,163	782,776	8,407,966
Nevada	2,868,649	1,922,269	60,613	4,851,531
New Hampshire	1,096,875	731,250	475,000	2,303,125
New Jersey	2,864,310	1,041,631	5,527,987	9,433,928
New Mexico	3,644,292	2,522,486	257,261	6,424,039
New York	10,834,758	4,272,294	18,776,072	33,883,124
North Carolina	5,431,717	4,452,710	1,492,475	11,376,902
North Dakota	3,341,784	2,408,093	214,578	5,964,455
Ohio	7,893,255	4,650,034	7,539,574	20,082,863
Oklahoma	5,064,288	3,719,690	1,348,164	10,132,142
Oregon	3,728,403	2,544,245	810,873	7,083,521
Pennsylvania	9,182,796	5,268,563	10,517,201	24,968,560
Rhode Island	1,096,875	731,250	1,123,049	2,951,174
South Carolina	3,056,219	2,521,950	654,032	6,232,201
South Dakota	3,532,306	2,513,886	222,116	6,268,308
Tennessee	4,772,002	3,670,485	1,593,037	10,035,524
Texas	14,263,977	10,047,099	4,464,068	28,775,144
Utah	2,535,953	1,688,869	433,731	4,658,553
Vermont	1,096,875	731,250	211,884	2,040,009
Virginia	4,112,674	3,190,410	1,491,272	8,794,356
Washington	3,533,693	2,392,694	1,467,429	7,393,816
West Virginia	2,473,214	2,079,766	807,692	5,360,672
Wisconsin	5,430,678	3,678,326	2,654,463	11,763,472
Wyoming	2,794,242	1,896,157	133,049	4,823,448
Hawaii	1,096,875	731,250	393,416	2,221,541
Dist. of Col.	1,096,875	731,250	1,146,477	2,974,602
Puerto Rico	1,107,133	1,130,464	834,529	3,072,126

MANUFACTURERS' DIVISION

of the

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These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

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Crushing, Screening, Washing, Grinding, Cement Machinery; Motors; Texrope Drives; Centrifugal Pumps; Tractors

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Primary and Secondary Crushers, Rolls, Screens, Elevators, Conveyors—Complete Plants designed and equipped

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MANUFACTURERS' DIVISION of the NATIONAL CRUSHED STONE ASSOCIATION

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Rock and Gravel Crushing and Screening Plants, Jaw Crushers, Roll Crushers, Hammer Mills, Lime Pulverizers

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A complete line of Power Excavating Equipment, Overhead Cranes, Hoists, Smootharc Welders, Welding Rod, Motors and Generators

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Asphalt Paving Machinery, Sand and Stone Dryers, Dust Collectors

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Manganese Steel Castings, Dipper Teeth, Crawler Treads, Jaw Plates, Concaves and Hammers

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Complete Stone Preparation Plants. Conveyors, Elevators, Screens, Washing Equipment, Speed-o-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

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Woven Wire Screens and Wire Cloth of Super-Loy, Manga-Loy and all commercial alloys and metals

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Marion, Ohio
A Complete Line of Power Shovels, Draglines and Cranes

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Complete Pit. Mine and Quarry Equipment —Crushers. Washers, Screens, Feeders, etc.

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Limestone Pulverizers; Jaw, Roll, and Hammer Crushers; Elevators; Revolving and Vibrating Screens; Dewaterers; Belt and Apron Conveyors; Conveyor Belting; V-Belts; V-Belt Drives; Engines; Electric Motors; Concrete Mixers with or without Power Lifts

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Nordberg Mfg. Co.
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Cone, Gyratory, Jaw and Impact Crushers; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens; Grizzlies; Diesel and Steam Engines; Compressors; Mine Hoists; Track Maintenance Tools

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65th St. South of Denison, Cleveland, Ohio
Dust Collecting Systems, Fans—Exhaust and Blowers

Northwest Engineering Co.
28 E. Jackson Blvd., Chicago, Ill.
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Pioneer Engineering Works, Inc.
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Pit and Quarry Publications
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Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

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Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines. Diesel Electric, Gasoline. 3/8 to 2-1/2 cu. yd. capacities

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Explosives and Blasting Supplies

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Wire Screens, Screening Machinery, Scrubbers, Testing Sieves and Dryers

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